REPORT
OF
CONSTRUCTION PLANT
AND
MACHINERY COMMITTEE
1972

VOL. I (REPORT)

GOVERNMENT OF INDIA
MINISTRY OF IRRIGATION & POWER
NEW DELHI

REPORT OF
CONSTRUCTION PLANT AND MACHINERY COMMITTEE

1972

VOL. I (REPORT)

S.P. CHUGH,
OSD (Chief Engineer),
Chairman, C.P.M.C.

D.O. No. 1/1/70/*PMG.*
GOVERNMENT OF INDIA
Central Water & Power Commission
(Water Wing)
Construction Plant & Machinery
Committee, Bikaner House,
Shahjehan Road, New Delhi-11,
the 30*th June*, 1972.

My dear Sir,

It is almost 18 years since the first Construction Plant & Machinery Committee Report was published in 1954. Our report, second in sequence, is presented at a time when the complexity of construction jobs has increased and the equipment employed thereon has become more sophisticated and expensive.

The First Committee had the onerous responsibility of defining the Standard Practice to be followed by the river valley projects in planning, operation, maintenance and repair of equipment, accounting of costs and training of Operators and Mechanics. The main objective was to suggest an all-encompassing management role, so that all those employed on construction work get properly involved in increased productivity and economy and thus lead to the utmost benefit to the job at hand. This provided the guidelines for pre-planning of tasks/jobs by using a standard method—a method that would have been standardised within an organisation for the type of work under certain job conditions.

The Report of that Committee has been the book of reference for all major users of equipment in the country, even outside the river valley projects, since, in the mean while, the field of application of such equipment got extensively widened to cover land reclamation, the mining industry—coal, iron ore, lignite, and other minerals and metals, road construction and port development etc.

With a view to sharing experience and pooling of information by all major users of equipment, our Committee was constituted, enlisting participation of nominated representatives of other major users—the N.M.D.C., the N.C.D.C., Ministry of Transport, D.G.B.R., and a leading manufacturer of equipment in public sector. Joint deliberations and visits to the works of users in different sectors acquainted the Committee with the techniques and methods employed in the country in management of operation, maintenance, repair and utilisation of equipment. The common problems faced by the equipment users in improving management and utilisation of equipment could thus be better identified and suggestions made for overcoming these.

It is our observation that the standard practices as previously recommended, have become more a matter of routine even though it should be normally expected that anyone intimately acquainted with the work being done would always have the opportunity to effectively devise new and better methods of doing the jobs more economically and faster.

In fact, there are areas of deficiencies and short-comings which have generally come in the way of satisfactory performance and utilisation of equipment. It was, therefore, necessary to elaborate the technical details of subjects covered by the terms of reference so that the subject of 'Equipment Economics' is better understood.

The task assigned to our Committee, as specified in the terms of reference, is more of the nature of a general study about the deficiencies and shortcomings, reasons contributing to the same and the measures/methods necessary to improve the existing position. Accordingly, it has been our attempt to suggest ways and means to improve the existing methods of work, so that less physical effort is required to achieve a reasonable productivity from the machines for the wages and other costs incurred. Some of the suggestions may seem rather elementary and a sophisticated person may pass them by. Some may even consider the suggestions as an insult to a reasonable man's intelligence. These are only common reactions and attitudes. We are well aware of the common belief on part of some that "No one could solve their problems, but themselves." Those managing equipment operations are often heard to say, "My work is different". This would not mean that the whole concept of methods improvement is being summarily dismissed in the belief that they are already accomplishing the same results without the bother of any organised, or formal techniques for methods improvement. The acceptance of scheduling techniques, such as 'CPM' , and 'PERT& by construction agencies/projects and the testimony of significant savings in time and more through their use, are proof that new ideas are not always ignored. Evidently, the organisations use the overall job planning techniques; but only few take the next step to organise and plan the tasks in different segments of work. The techniques for task planning, closely parallel those of project planning, now in wide use. They involve a detailed consideration of the site, tools, man-power and tasks. Ideally, most operations should be preplanned. Realistically, however, planning is applied as a corrective action only after a loss or poor organisation became apparent.

In order that planning of equipment is done more realistically in future, by all major users of equipment, it would be necessary to establish a suitable coordination system for exchange of technical information and for mutual sharing of experience in operation, repair, maintenance and overhaul of equipment. We are fully convinced that a suitable organisation has to be created at one focal point for effective coordination of this type, so that the common problems can be solved in a simple manner by collective thinking, participation, and joint actions. Such means of communication would give an incentive for work improvement methods and techniques—time and methods studies, operations research, work sampling, etc., etc., to be put to use. Unfortunately, such techniques are not in use as widely as we may desire. This organisation will also be the Coordinating Agency on behalf of the major users of equipment for matters relating to: import trade control policies and procedures; indigeneous manufacture of equipment and spare parts of proper design and quality; preparation of a central record of norms and standards for production with different types and categories of machines; their costs—operational, repair, maintenance, etc.; simplification of procedures for procurement of spare parts and equipment; enforcement of formalised training programmes; review of information on inter-changeability of parts; standardisation of equipment etc., etc.

We have accordingly, suggested the constitution of a Standing Committee of Equipment Planning, comprised of members to be nominated by the major sectors using such construction plant and equipment on a large scale. The Irrigation and Power Sector being the major user of such equipment (they own equipment worth Rs. 1400 million out of a total of Rs. 3500 million worth of equipment in the country) may establish the proposed Committee in consultation with other departments/public sector undertakings who will be listed as partners in this.

The effectiveness of the work to be done by this Committee could be achieved only if the equipment operating authorities follow a proper method of record keeping in relation to all activities of the equipment in use. Even though there is a greater awareness in the mind of an average equipment user, for entailing economy to equipment operations, an analytical approach is not made by them for cost evaluation and cost effectiveness, based on defect analysis reports relative to machines in use. This is a direct handicap resulting from poor record keeping.

Another subject for joint venture or mutual participation by all is the training of operators, mechanics and supervisory personnel. For proper control in establishment and operation of Technical Training Centres, to impart formalised training to Operators and Mechanics, whether in the I&P Sector, or under the aegis of other important sectors using such equipment, it has been suggested that a Governing Body be constituted comprised of members from the I&P Sector, mining sector, the road building sector the Planning Commission and the Ministry of Finance. This organisation will review the curricula and syllabi of the training courses in the Technical Training Centres, with a view to enforcing uniformity in standard of education in this field. The envisaged participation and partnership of all major users of equipment would help produce better standards of training.

It is also our opinion that, in addition to the training of Operators and Mechanics, is necessary to train Supervisors and other executives in the Technical Training Centres, so that they can have a better control on operation and repair activities while equipment is on the job.

From the management angle the supervisory and executive personnel managing operation, maintenance, repair and overhaul of equipment, should necessarily familiarise themselves with other important aspects relating to equipment selection, job application, work improvement methods, time and methods studies, operation, maintenance and repair techniques etc., etc. Such training can be imparted by introducing training courses of 6 to 8 weeks duration in the CW &PC. The trainers in this case would be selected from different sectors using large sized fleets of such equipment, so that the instructions imparted are beneficial to all the trainees by keeping them fully abreast with the latest trends in development of methods and techniques of proper used and control of modern sophisticated equipment.

It is encouraging to observe that the need for formalised training of Operators and Mechanics has been admitted by all; and some of the major sectors have expressed their desire to establish T.T.Cs., under their own control. Whereas, it would be more beneficial to continue such training programmes as a joint venture, in the event of others establishing such institutes individually, exclusive consideration has to be given to the running and maintenance of the T.T.Cs. of the CW&PC. Unfortunately, questions hav been raised in the past about the need for continuance of out T.T.Cs. These have mainl involved the financial expenditure aspect, specially when the river valley projects have shown some reluctance in sponsoring the trainees for such training. Exclusive consideration has, therefore, been given to establish active association and partnership of all the river valley projects in the country, so that running and maintenance of the T.T.Cs. and organising a continuous training programme could get a firm footing.

Besides suggesting replacement of present equipment in the Training Centres by equipment models of more recent origin, a recommendation has been made to provide for the expenditure on training of Operators and Mechanics, as well as supervisors and other executive staff, by making a provision in the project estimates at the rate of one-fourth to one-half of one per cent of the estimated cost of the project, 50% of this provision may be utilised by the project authorities for in-service-training expenditure while the balance amount of provision may accommodate the expenditure on training through the Technical Training Centres and the training facilities to be organised by CW&PC for training of supervisors and executives.

On the training aspect, we would also suggest that six model projects/work sites of production unit making large scale use of equipment in different sectors, should be selected for deputing officers to take training in mechanised construction methods and management of operations with equipment. This may be on the same pattern as that of training abroad in the past of some of the engineers in this field.

We are also convinced that the skill and technical know-how of the Indian Engineers matches their counterparts in foreign countries in relation to modern methods and techniques of construction/production with construction plant and equipment. What is required is more meticulous planning of work with equipment and better efficiency in management thereof, which alone can entail economy in construction/production costs. Emphasis is therefore, to be laid on creating proper organisation for equipment management and administration. Organisation is the machine of management, and unless it function properly, it may be difficult to achieve the required efficiency. The present pattern of such organisation indicates divided responsibility, delegation of authority not commensurate with responsiblity, not too effective coordination of activities and lesser emphasis on specialisation. For equipment management and administration to be successful, it is necessary to reorient its pattern on unitary control basis, so that functionally the entire process of equipment planning, operation, maintenance, repair etc., to the point of discarding the equipment at the end of its economic life, may be assigned to a well-knit equipment organisation. What is required is frictionless inter-divisional activities within the organisation, and the assignment of responsibility with commensurate authority to competent persons who have specialised in the work with equipment.

This assumes much greater importance in the context of the envisaged programme of development in the country in future. The working paper on 'Approach to the Fifth Plan' underlines the need for more concerted action in achieving the targets in various fields of production, when the outlay is expected to be twice as much as for the 4th plant Schemes. The growth in population of equipment in the country in the next five years may, therefore, be expected to be greater than ever before. It is, therefore, more important now to strengthen the organisations managing the equipment in different sectors, so that their efforts are properly directed to reduce investments, ensure greater productivity from the machines by more meticulous planning of equipment operations and better availability through proper operation, maintenance preventive maintenance and repair of equipment. We have accordingly, made suggestions in our report for evolving a proper pattern of the equipment organisation.

In substance and in essence, the recommendations made by the first Construction Plant and Machinery Committee and our Committee, are similar. The difference is in the details and text of the subjects covered by them. As already stated, our report has been made more elaborate than the previous one, so that individual recommendations are better understood in proper context by an average user of equipment. Even so, unless an average user of equipment implements the recommendations in actual practice, it may be difficult to expect much of improvement in performance and utilisation of equipment. We consider it necessary that every major sector using equipment should create a top level equipment management and coordination organisation for this purposes.

It is also necessary that for ensuring greater awareness in the minds of equipment users regarding cost evaluation and cost effectiveness, the accounting system relating to ownership and operating costs of equipment should be suitably modified. The old PWD system of accounting should undergo a change to accommodate partially the commercial pattern which affords the convenience of "Ready at a Glance Reckoning" and evaluation of costs in different segments of work with equipment. The notional approach to balance the actual costs with estimated costs by apportioning a part of the expenditure not incurred to the cost of work, has to be dispensed with. Moreover, better control has to be the exercised in preparing financial budgets an control estimates in respect of spare part which account for expenditure equivalent to 100% to 300% of the cost of the machine, in their life-time in service, Simple apportioning of the cost of spare parts to the works through estimated hourly rates of use of the equipment does not afford the convenience of exercising proper control in expenditure.

Undoubtedly, accounting is a means of keeping a watch on economy in expenditure. In relation to equipment the main item of expenditure is the maintenance materials including spare parts. Investments can be reduced by regulating the size of stocks of spare parts by introducing the inventory control system, establishing a scale for provision of spare parts and scaling out requirements for procurement based on pattern of consumption. Unfortunately, the inventory control system has not been put to use properly, except by a very few users of equipment. Regarding the scale of provision of spare parts, the Committee have attempted to furnish guide lines based on evaluation of data and information collected from the users of equipment. As for the scale of consumption of spare parts, this can be better assessed by accumulating data and information relative to consumption of spare parts on given items of machines. Proper scaling of requirements of spare parts for forward planning of procurement thereof, can be as sound as the record indicating scale of consumption of individual items—atleast those of high value. It is gratifying to note that, in response to the few suggestions, the Commitee could give in this respect to the various users of equipment during the visits to their work sites in different sectors, some of them have already developed record keeping systems to establish a scale of consumption of items. Further action has to be taken on 'compaign basis' for effective introduction of this system in all equipment organisations.

There has been unanimity in the thinking on part of all Members of the Committee in the matter of establishing a Coordination Cell in the CW&PC for creating a central record of data and information on all aspects incidental to use of equipment working in different sectors in the country. Emphasis has also been laid on early establishment of a Plant Planning Directorate in the CW&PC. The Coordination Cell and the Plant Planning Directorate would provide the main support for technical examination of proposals and other items for consideration by the Standing Committee on Equipment Planning. Even otherwise, for economy in investment costs in equipment and its supporting facilities required for any project in the I&P Sector, proper functioning of the Plant Planning Directorate in the CW&PC is very essential. Unless this is done immediately, we will continue to face the rather disturbing position of underutilisation of equipment, disproportionately large investments in equipment, facilities and stocks of spare parts on the projects.

In conclusion, it may be stated that if we have to get wiser by the past experience in facing the realities of the present and fulfilling our aspirations of the future, we must admit the need for enforcement of measures to evaluate economy relative to every task in different segments of work with equipment and create a sound organisation for planning, execution and review of the tasks to be performed within its environments. Planning would need the prime attention in all its facets. Execution would involve work improvement methods and techniques with the main support of proper records. The defect analysis made from a well maintained record would enable proper cost evaluation and the consequent identification of measures for cost effectiveness. We are of strong conviction that even if thorough planning of the work at the inception of a project results in a small delay in execution, the resultant initial handicap in time will be made good by the expedition in work later. In any case, the total investment in expenditure will be comparatively reduced.

All this, of course, is subject to availability and allotment of adequate funds and foreign exchange which shall have to be provided in a sustained manner.

Great stress has been accordingly laid in the report and in the summary of recommendations, on following certain standard practices on planning, execution, and record keeping etc., in the relation to work with equipment.

It is piously hoped that suitable steps will be taken to implement the recommendations that have been made by this Committee. This will cause better utilisation of equipment in the country and reduce future investments in equipment, spare parts and other facilities. Generally required for proper operation and upkeep thereof. This would also help in avoiding further probe of the type made by our Committee—more so when the CW&PC through their central Coordination Cell, the Plant Planning Directorate and the Ministry of Irrigation and Power through the Standing Committee on Equipment

Planning, would cause continuous updating of all information relating to equipment availabe in the country.

We foresee much brighter prospects even in the matter of identification of items of construction plant and Equipment to be indigenously manufatured in the country, as the Equipment Standing Committee would be able to give proper technical guidance necessary for the purpose, in selection of items of quality and proper standard for manufacture.

Normally, the Committee should have finalised their report only after their findings and observations had been discussed in a Seminar in which the representatives of major users of equipment, in different sectors, would have participated. This is what was done before the report of the First Committee was finalised. However, since a colossal amount of work was involved in relation to the terms of refernce of the Committee, deliberations of the Committee continued upto the middle of June, 1972; and this delayed the finalisation of the draft report. Accordingly, it was not possible to arrange for a Seminar to be held.

All the same, the Members of the Committee individually and collectively discussed most of the important points of observations and recommendations in meetings with a large number of Engineers/Managers/Supervisors, controlling operations/ management of equipment in different sectors. The observations and recommendations as now made are in general agreement with their views.

It may perhaps help in avoiding a bulk of correspondence work, which may arise from the references from users of equipment in different sectors (seeking clarifications or communicating their comments on the text or the recommendations in the report), if the report is discussed in a Seminar. The advisability of holding a Seminar may, therefore, be considered by the Government, before the report is accepted and got printed. The Members of the Committee would be very happy to participate in such a Seminar, if held.

I am grateful to you for the opportunity given to discuss the views of the Committee in certain policy matters of technical importance. This has been of immense help and gave us lot of encouragement in finalisation of our recommendations.

With regards,

Yours sincerely,
Sd/-
(S.P. CHUGH)

Shri B.P. Patel,
Secretary to the Government of India,
Ministry of Irrigation & Power,
Shram Shakti Bhawan, Rafi Marg,
New Delhi-1.

CONTENTS

PAGE No.

Introduction . . . . (xiii)

Summary of recommendations . . . . (xxi)

Gist of some important Norms & Standards recommended as guidelines . . . (xxxv)

CHAPTER 1 Appraisal of the Construction Plant and Equipment in the country . . . . . 1—20

1.1 Background and history 1

1.2 Population of equipment 3

1.3 Sector-wise distribution of equipment 5

1.4 Categories and makes of equipment 5

1.5 Assortment of makes and models of equipment 5

1.6 Indigenous Equipment 10

1.7 Physical life of equipment in use 13

1.8 Performance and Health of Equipment 14

1.9 Observations of the Committee 15

1.10 Summary of observations and recommendations 18

CHAPTER 2 Assessment regarding level of utilisation of available Equipment . . . . . . 21—29

2.1 Need for Equipment Scheduling for assessment of utilisation 21

2.2 Availability factor for equipment scheduling 22

2.3 Fixation of Schedules 23

2.4 Economics of multishift operation 25

2.5 Accomplishment by way of actual utilisation of equipment by different users . . 27

2.6 Observations 28

2.7 Summary of observations and recommendations 28

CHAPTER 3 Reasons for low utilisation of equipment and low efficiency in operation and remedial measures necessary for improving efficiency in the operation of equipment and for optimum utilisation thereof . . . . 31—46

3.1 Areas of analysis 31

3.2 Reasons for low utilisation 31

3.3 Discussion on the reasons for low utilisation and suggestions for remedial measures . 32

3.4 Summary of observations and recommendations 45

CHAPTER 4 Procedure, System and Methods of Procurement of Spare Parts and Inventory Control . 47—71

4.1 Importance of the System 47

4.2 Magnitude of Problem 47

4.3 Reference to a Paper Published at I.R.F. Seminar 48

4.4 Existing System and Method of Procurement 49

4.5 Functioning of the Present System and Measures for Improvement 51

4.6 Factors Considered for the System 61

4.7 Surplus Stock 68

4.8 Summary of observations and recommendations 69

सत्यमेव जयते

PAGE No.

CHAPTER 5 Requirement of equipment during the 4th Five Year Plan, Import Substitution and Standardisation 73–84
5.1 Requirement during the 4th Plan 73
5.2 Tentative assessment of requirement of equipment during 5th Plan Period . . . 77
5.3 Import Substitution 77
5.4 Standardisation 82
5.5 Summary of observations and recommendations 83

CHAPTER 6 Inter-departmental coordination in matters relating to Construction Plant & Equipment with emphasis on inter-departmental transfer of surplus equipment . . . . . . 85—102
6.1 Necessity for coordination 85
6.2 Subjects of inter-departmental coordination 86
6.3 Coordinating Cell 86
6.4 Standing Committee on equipment planning—need for establishment & functional relationship with other co-ordinating agencies/establishments 87
6.5 Inter-departmental transfer of surplus equipment 90
6.6 Coordination in determination of availability of spare parts for like items of equipment with various users in the country 93
6.7 Coordination in developing interchangeability of parts relative to different makes of machines 95
6.8 Coordination in the matter of indigenous manufacture of spare parts 96
6.9 Management and control of equipment 98
6.10 Conclusion 99
6.11 Summary of observations and recommendations 100

CHAPTER 7 Training of Operators & Mechanics . . . . 103—116
7.1 Introduction 103
7.2 Operators and Mechanics Training 103
7.3 Existing training programme 105
7.4 Need for improvisation of the training methods, techniques & facilities . . . 107
7.5 Formulation of training programme for future 108
7.6 Management 110
7.7 Financing 112
7.8 Alternative proposals made by major users of equipment for individual ownership and management of the Technical Training Centres 113
7.9 Views of the Committee 114
7.10 Placement of trained personnel 114
7.11 Conclusion 114
7.12 Summary of observations and recommendations 115

CHAPTER 8 Data on performance of different items of equipment of various categories/makes . 117—139
8.1 Scope 117
8.2 Technical assessment on performance of various items of equipment 117
8.3 Norms for Schedules of working hours & life of equipment of various items . . . 123
8.4 Major repair and field repair charges over the last 10 years, in respect of various items of equipment in terms of (1) Spare Parts, and (2) Labour 132
8.5 Summary of observations and recommendations 137

CHAPTER 9 Hire Charges of Equipment . . . . 141—150
9.1 Need for hiring out equipment 141
9.2 Need for evaluating hire charges 141

PAGE NO.

9.3 Concept of Hourly Ownership and Operating Cost 142
9.4 Hourly Ownership & Operating Cost for accounting hire charges 142
9.5 Existing system of Hire Charges 143
9.6 Uniform basis for assessment of hire charges 143
9.7 Terms and Conditions 147
9.8 Summary of observations and recommendations 149

CHAPTER 10 Maintenance Procedures . . . . 151—169
10.1 Definition 151
10.2 Functions of maintenance 151
10.3 Types of maintenance 151
10.4 Maintenance procedure as adopted by the different users 151
10.5 Scheduled maintenance 155
10.6 Preventive maintenance 156
10.7 Breakdown maintenance 161
10.8 Functional requirements of maintenance 161
10.9 Facilities for maintenance and repairs 162
10.10 Additional considerations 166
10.11 Summary of observations and recommendations 168

CHAPTER 11 Organisational set up in including workshop facilities, stores, warehouse etc . . 171—190
11.1 Introduction 171
11.2 Organisational set up 171
11.3 Maintenance and repair facilities—relative considerations 171
11.4 Maximum self-maintenance—considerations for essential facilities 173
11.5 Stores warehousing 186
11.6 Observations of the Committee on visits to sites of work of different users of the equipment 187
11.7 Summary of observations and recommendations 188

CHAPTER 12 Organisation and functioning of Central Mechanical Units in Irrigation and Power Sector and similar other Establishment in other Sectors . . . . 191—202
12.1 Establishment of Central Mechanical Units in Irrigation and Power Sector . . 191
12.2 Assessment of the present position 193
12.3 Observations of the Committee 196
12.4 Conclusions 199
12.5 Co-ordination—Activities in other major Sectors 200
12.6 Summary of observations and recommendations 201

CHAPTER 13 Accounting for the ownership and operating cost per plant hour . . . . . 203—230
13.1 Purpose 203
13.2 System 203
13.3 Depreciation 203
13.4 Interest Charges, Insurance & Taxes 211
13.5 Repair cost 212
13.6 Other Operation Costs 215
13.7 System of accounting 218
13.8 Accounting 220
13.9 Summary of observations and recommendations 229

PAGE No

HAPTER 14 Management, operation and utilisation of construction plant and equipment—recommendations for . . . . 231—258

14.1 Management and Organisation—need for. 231

14.2 Definitions 231

14.3 Organisation 231

14.4 Deficiencies in existing Management Organisations of equipment users 234

14.5 Organisational set up for large scale equipment operation in different Sectors—a study . 236

14.6 Equipment Organisation—the proposed pattern 239

14.7 Training of Executives & Supervisors 242

14.8 Other important considerations for attaining high efficiency in management. . . . 244

14.9 Role of various organisations in achieving efficiency in management of equipment . 253

14.10 Computors—a controlling aid for economy in use of equipment 254

14.11 Views of eminent Indian Engineers on pattern of organisation and management of construction plant and equipment 255

14.12 Summary of Observations and recommendations 257

सत्यमेव जयते

INTRODUCTION

Large scale mechanisation of construction work on River Valley Projects started soon after Independence. The D.V.C. Complex, the Hirakud Dam Project and the Bhakra Dam Project were the first major projects involving heavy concentration of equipment at individual locations. To start with, only such equipment was deployed on the job as was readily available from within the country—mainly from the Defence surpluses at the end of World War II. The Indian Engineers, who were almost new to such equipment, accepted the challenge to manage the operation, maintenance and repair of the equipment by mustering the Indian skill and labour. The process of commissioning surplus equipment and sustaining it in operation on the job was more of an exercise of cannibalisation of machines, replacement of assemblies and components or in some cases rebuilding of the parts.

For future planning, regarding additional equipment for major Projects and other smaller projects in the Irrigation and Power Sector, the Indian Engineers had to work in close collaboration with Colombo Plan Experts and T.C.M. or U.S. A.I.D. Technicians abroad or those posted in India. Simultaneously, intensive studies had to be made regarding construction methods and techniques adopted in other countries in the contemporary world, where mechanisation of construction work had gained good momentum, partly by deputing a few officers to visit such works in foreign countries and partly by studying project reports obtained through various experts/agencies.

The development of construction equipment in foreign countries in late 'Forties' and early 'Fifties' was comparatively slow. A large number of new manufacturers were entering the field of equipment manufacture and the equipment put to the market was not fully proven.

With the rapidly growing need of equipment on River Valley Projects and with the limitations and constraints imposed by the terms and conditions of the aid/credits/loans, against which such equipment was to be purchased and imported, selective choice of equipment could hardly be made. In this process some difficulties arose in respect of management of operation, maintenance, repair and utilisation of equipment etc., specially when the native skill was yet in the process of development.

The progress in construction work mainly depended upon effective utilisation of the machines. For this to be so it was necessary that the Indian Engineers got fully conversant with the proper methods of management, operation, maintenance, repairs etc., of the construction plant and equipment. It was desirable that there should be uniformity in the standards and norms to be followed in the matter of planning for equipment, apportioning labour costs and repair costs to the works, record keeping, the maintenance procedures and training of personnel etc.

Accordingly, the Government of India, Ministry of Irrigation and Power appointed a Committee of Engineers to visit some of the projects then under execution and to submit a report on the economic and efficient operation and maintenance of the plant and machinery used in the construction work of river valley projects in the country. The terms of reference to that Committee were as under:—

1. The makes, types and sizes of the plant best suited for various types of work with a view to standardisation;
2. combination and matching of plant where more than one unit of plant is involved;
3. correct apportionment of labour to plant;
4. mode of calculation of the working cost of each type of plant per hour; the unit cost of the work performed by each type of plant on the various projects should be computed for the last working season and variations in cost should be explained;

5. suggestions for a unified scale of depreciation;
6. standard forms for the history sheets and log books of each type of plant;
7. the various factors involved in efficient plant operation emphasising the adverse factors which have been responsible for low output and poor maintenance on the various projects visited; and
8. comparison of costs of work being carried out by machinery with that carried out by manual labour with recommendations as to the type of work which should be normally carried out with machinery.

The Report of that Committee (——named as "Report of Construction Plant and Machinery Committee"), was published in 1954. This has been the book of reference for prescribing standard practice instructions in relation to equipment operation, maintenance and cost evaluation not only for the river valley projects in the country, but also for most of the users of similar plant and equipment in different sectors —— mining, land reclamation, road building, port development etc.

An abstract of recommendations made in the Report of that Committee is at Appendix 0.1.

Over the last two decades, the construction plant and equipment found in-roads to a fairly large number of industrial areas — iron ore mining, coal mining, lignite mining, road building, land reclamation, port development and agriculture. The population of construction plant and equipment has substantially increased during successive five year plan periods; and as of 30-11-1970 it is Rs. 3500 million by value and 20000 by numbers (approximate figures). In the Irrigation and Power Sector alone, equipment worth Rs. 1400 million is in operation, when during the year 1953-54, equipment worth Rs. 400 million only was with them. These figures are clearly indicative of the increase in the intensity of mechanisation, the level of imports in the past and the potential of indigenous manufacture of the equipment.

In view of the emphasis on self-reliance, self-sufficiency, and import substitution programmes of indigenous manufacture of equipment were effectively introduced in late 50's and early 60's. Even though the development of such programmes has been rather slow, the country has now come to a pass where, by the end of the 4th Plan period, almost 80% of the requirement of major items of equipment could be met with from indigenous sources.

It is rather unfortunate that for various reasons, productivity of the machines has been low and the production levels have not been commensurate with the total investment in the equipment in various sectors. This is due partly to some delay in procurement of maintenance and repair supplies and partly to low utilisation of equipment for other reasons. The resultant situation as such has been a matter of concern with the Government and the equipment owning authorities. The matter has been under constant review for making a precise assessment of the reasons to which low utilisation of equipment could be attributed. The main area in which some of the difficulties could be precisely located related to resources provision — by way of foreign exchange allocations, the Import Trade Control policies and purchase procedures, which caused delay in procurement of equipment and spare parts.

In order to recommend necessary measures for elimination of delays in procurement of equipment and spare parts for river valley projects, the Government constituted a Committee of Ministers to go into the matter. One of the recommendations of that Committee was that the Government should constitute a Construction Plant and Machinery Committee to compile necessary statistical data regarding population of construction equipment in the country, to lay down norms regarding productivity of different items, of equipment, unit cost of work with different machines, standardisation of equipment etc., etc., so that technical examination can be done in a uniform manner.

Accordingly, the Ministry of Irrigation and Power *vide* Memo. No. 6(5)/69-Policy/Mat. dated the 31st October, 1970, appointed the present Construction Plant and Machinery Committee. Letters of the Ministry of Irrigation and Power in this context are at Appendix 0.2.

The Constitution of the Committee is as follows: —

Constitution.

1.	Shri S.P. Chugh, OSD (Chief Engineer), CW&PC, Water Wing	Chairman
2.	Shri Jagman Singh, Superintending Engineer, Mechanical Circle, Beas Project, Unit-II, Talwara.	Member (Part-time)
3.	Shri B. Kotaiah, Superintending Engineer (Mechanical) Nagarjunasagar Dam Project, Andhra Pradesh.	Member (Part-time)
4.	Shri J.N. Srivastava, Director (Dams-II), CW &PC (WW).	Member (Part-time)
5.	Shri M.C. Praharaj, Deputy Director, CW&PC (Water Wing).	Member-Secy.

It was indicated that if necessary, the Committee may co-opt members from other interested organisations like National Coal Development Corporation, National Mineral Development Corporation, Hindustan Steel etc. The Committee will be provided necessary supporting staff.

The terms of reference of the Committee are as follows: —

(i) Appraisal of the Construction Plant and Equipment in the country;

(ii) Assessment regarding level of utilisation of available equipment;

(iii) Reasons for low utilisation of equipment and low efficiency in operation;

(iv) Procedure, system and methods of procurement of spare parts and inventory control;

(v) Remedial measures necessary for improving efficiency in the operation of equipment and for optimum utilisation thereof;

(vi) Requirements of equipment in the Fourth Five Year Plan, import substitution and standardisation;

(vii) Inter-departmental co-ordination in matters relating to Construction Plant and Equipment with emphasis on inter-departmental transfer of surplus equipment;

(viii) Training of operators and mechanics—Review of adequacy of present arrangements etc.

(ix) Data on performance of different items of equipment of various categories/makes;

  (a) Technical assessment;

  (b) Norms for schedules of working hours and life of equipment of various items;

  (c) Actual performance of various items of equipment in different projects in various sectors in terms of average annual utilisation and the life usefully spent on different jobs over given periods;

  (d) Major repairs and field repairs—Charges over the last ten years, in respect of various items of equipment in terms of;

    (1) Spare parts; and
    (2) Labour.

(x) Hire charges of equipment;

(xi) Maintenance procedures;

(xii) Organisational set-up, including workshop facilities, stores and warehouses etc.

(xiii) Organisation and functioning of Central Mechanical Units in Irrigation and Power Sector and similar other establishments in other sectors;

(xiv) Accounting for the ownership and operating cost per plant hour;

(xv) Recommendations for management, operation and utilisation of construction plant and equipment.

The terms of reference imply a deep examination of all major aspects of work incidental to operation, maintenance, repair and management of equipment for optimum utilisation. The main object being overall economy in end cost of production with the machines, the entire process of planning, selection, maintenance and repairs, rehabilitation of surplus equipment, record keeping, cost analysis and cost evaluation, has to be established, keeping in view the present practices and procedures followed by major users of such equipment in the country.

सत्यमेव जयते

The magnitude of the task before the Committee in preparation of the report is stupendous, considering the time at their disposal and the staff sanctioned to carry it out. Tabulation, analysis and sampling of information received from 298 Nos. of users of equipment was an uphill task. Moreover, back references were necessitated to the projects/users of equipment as the data given was inadequate or incomplete in many cases. This was evidently a result of inadequacy of the record keeping system with the users of equipment. Therefore, even though the tenure of the Committee was initially fixed as one year, the work could not be completed in the scheduled time. The tenure of the Committee was consequently extended to the end of June, 1972.

The Committee are to be assisted by one Assistant Director and the following other staff: —

Stenographer Grade II	1 No.
Stenographer Grade III	1 No.
Upper Division Clerk	1 No.
Lower Division Clerk/Typist	1 No.
Peons	2 Nos.

The Chairman assumed duty on 26-11-1970 and the Member-Secretary on 30-11-1970. Two Members joined in December, 1970, while the third member joined on 13-3-1971.

The other members of staff joined the Committee on the dates noted against each: —

Assistant Director	1-12-1970
Stenographer Gr II	26-11-1970
Stenographer Grade III	30-12-1971
Upper Division Clerk	16- 2-1971
Lower Division Clerk	8- 1-1971
Peon	1-12-1970

The other peon was not posted.

Following is the list of the Coopted Members who were nominated on the Committee: —

Co-opted Members: —

1. Shri P. K. Thakur, Chief Engineer (Roads), Ministry of Transport and Shipping (Roads Wing), Parliament Street, New Delhi.
2. Shri N. Guha, Senior Mechanical Engineer, M/s. National Mineral Development Corporation Ltd.
3. Shri H. S. Srinivasan, Chief Engineer (Excavation), M/s. National Coal Development Corporation Ltd., Ranchi.
4. Chairman, Tractor, Earthmoving and Construction Equipment Distributors' Association — Shri W. Barreto upto June, 1971 and Shri Madan Agarwal from July, 1971.
5. Lt. Col. Jagjit Singh, D.G.B.R.
6. Shri Anil Salgaocar, Goa Mineral Ore Exporters' Association.
7. General Manager (Commercial), M/s. Bharat Earth Movers Ltd., Bangalore— Shri K. Ray upto July, 1971, and from September, 1971 Lt. Col. G.K.K. Iyengar.
8. Chief Project Officer, M/s. Hindustan Steel Construction Works Ltd. — Shri A. K. Ramayya upto September, 1971 and Shri H. C. Gupta, Dy. Chief Engineer from October, 1971.

The Committee started functioning from December, 1970. During the first month of its formation, a set of proformae and questionnaire were developed and circulated, calling for information from almost all the users of equipment in the country — in Central/State Government Departments, Irrigation and Power Projects, Public Sector Undertakings/Corporations and Private Sector. Replies to the questionnaire and information in prescribed proformae started arriving from March, 1971 but the bulk of information was received from July, 1971 onwards.

Members of the Committee started visiting projects from February, 1971 onwards for examining the existing systems, methods, procedures and facilities for operation, maintenance and repair of equipment, the type and pattern of organisation controlling such work, the system of accounting of costs, record keeping, etc., etc. During these visits, detailed discussions were held with the project authorities to ascertain details of the problems and difficulties faced by them in improving the utilisation of equipment and increasing the level of production by the available machines. In subsequent visits to other projects, the data and information received from those projects were jointly reviewed with a view to locating precisely the areas of deficiencies so that a specific view could be taken on measures to be introduced for improvement. The discussions were held with officers at various levels of management within the organisation on individual projects.

The thinking of the Committee on various aspects of the terms of reference was progressively given shape as a result of these discussions.

Members of the Committee visited the following projects/public sector undertakings/private enterprises:—

Irrigation and Power Projects:—

1. Bhakra Dam; 2. Beas Unit I; 3. Beas Unit II; 4. Ramganga; 5. Yamuna Hydel; 6. Tenughat Dam; 7. Hirakud Dam; 8. Balimela Dam; 9. Parambikulam Aliyar; 10. Mula; 11. Ukai; 12. Tawa; 13. Rajasthan Canal; 14. Nagarjunasagar Dam and Canal; 15. Pochampad; 16. Lower Sileru.

Public Sector Undertakings

(a) *M/s. Hindustan Steel Ltd.*

1. Bhilai Steel Plant and captive mines; 2. Rourkela Steel Plant and captive mines; 3. Bokaro Steel Plant.

(b) *M/s. National Coal Development Corporation Ltd.*

1. Barkakhana Collieries; 2. Kargil Collieries; 3. Barkhunda.

(c) *M/s. National Mineral Development Corporation Ltd.*

1. Bailadila Iron Ore Mines; 2. Kiriburu Iron Ore Mines; 3. Iron Ore Handling Plant at Visakhapatnam Port.

(d) Neyveli Lignite Corporation Ltd.

Other Projects

1. Badarpur Thermal Power Station; 2. Delhi Flood Control; 3. Madras Atomic Power Station; 4. Field Machinery Units of Rehabilitation Reclamation Organisation at Balimela Project and Bailadila Iron Ore; 5. Border Roads Workshops, Pathankot.

Private Bodies

1. M/s. V. N. Salgaocar & Brothers Pvt. Ltd.; 2. M/s. V. S. Dempo & Co. Pvt. Ltd.; 3. M/s. Sesa Goa Private Ltd.; 4. M/s. Hindustan Construction Corporation; 5. Patel Engineering; 6. Noamandi Iron Ore Mines of M/s. Tata Iron & Steel Co.

Manufacturers

(1) M/s. Bharat Earth Movers Ltd.; (2) M/s. Heavy Engineering Corporation; (3) M/s. Tata Engineering & Locomotive Co.; 4. Tata Iron & Steel Co.; 5. M/s. Tata Robins; 6. M/s. Ashok Leyland; 7. M/s. Hindustan Motors; and 8. M/s. Revati Machines Tools.

Views of the Committee on various terms of reference based on the data collected and the opinions expressed by the users of the equipment, were finalised in periodical meetings. Full Committee meetings were held 20 times during its tenure — 11 times at Delhi and on nine occasions at project sites. Besides these meetings, a number of group meetings attended by some Members and Coopted Members, were held at Delhi.

In order to avail of the experience and expertise with the principal dealers of equipment in the fields of maintenance and repair procedures, training of Operators and Mechanics, spare parts procurement and disposal, and rebuilding/conservation of worn out components/parts, the Members of the Committee had meetings with the dealers of equipment collectively, who are Members of the Tractor Earthmoving & Construction Equipment Distributors' Association.

At the specific request of the Union Ministry of Labour, Employment and Rehabilitation (Department of Rehabilitation) a special examination was carried out of the working o Rehabilitation Reclamation Organisation, wh maintain and operate a large number of field machinery units for land reclamation work in the country. This was in the normal proces of visits made to some of their field machinery units and a separate report submitted.

In response to a similar request regarding surplus equipment available with Rourkela Steel Plant and the policy for economic replacement of construction and mining equipment working on different projects of M/s. Hindustan Steel Ltd., detailed discussions were hel with the officers concerned during the visit o the Members of the Committee to the Rourkela Steel Plant. This also involved some correspondence with the Director (Finance), H.S.L. and the Finance Officer, Bureau of Public Enterprises. The observations of the Committee were rendered to the officers concerned.

With the background knowledge of the principal recommendations made in the Report of the Construction Plant & Machinery Committee in 1954, the general observation in terms of summary assessment by the present Committee is that an average user of equipment even in the Irrigation and Power Sector has not been fully guided by the direction of control suggested in those recommendations regarding planning for equipment, accounting, record keeping, the maintenance procedures and training of personnel, etc. In order to emphasise more strongly the need for implementation of these recommendations, this Committee has thought it fit to cover more comprehensively the context and technical details of subjects covered by individual terms of reference. An attempt has been made to make each chapter self-contained for comprehensive study. Since, however, the terms of reference are such as would involve certain common aspects of work control relative to equipment, repetitive reference to certain subjects in various chapters of the report could not be avoided.

The Committee have also attempted to seek expert advice on important matters from eminent engineers who have retired from very high positions in State/Central Government service. Exchange of views was also made with very senior officers/heads of organisations in Government Departments and Public Sector Undertakings in respect of suggestions and proposals formulated by the Committee, where coordinated and integrated effort is called for collectively from all States/Central/Public Sector Organisations. This is illustrated by the proposals for constituting

(i) Governing Body for Technical Training Institutes;

(ii). the Standing Committee on Equipment planning; and

(iii). uniformity in the method of accounting of depreciation and repair costs of equipment. Much as the Committee would have liked to cover more comprehensively the details of the forms etc., for record keeping, and outline of the Purchase Manual, a Handbook/Ready Reckoner giving emperical formulae and thumb rules for estimation of cycle-time, production, cost evaluation etc., it has not been possible for them to finalise this in view of the heavy load of assigned work.

The statistical information compiled and studies made by the Committee lead to conclusive observations pointing towards deficiencies and shortcomings generally resulting in poor performance of equipment with some individual equipment owning authorities. However, an assessment has been made in general terms of the reasons causing poor performance of equipment and recommendations have been made for corrective action. It is piously hoped that the projects/owners of equipment, would take corrective actions after studying the report properly and supplementing that by a critical study of the existing practices and procedures relating to equipment in operation with them. What is necessary is to introduce methods of improvement in equipment management and operations.

It is the considered opinion of the Committee that in future, the equipment owning authorities and the management, should themselves take to a proper system of planning for equipment, record keeping, defect analysis, cost evaluation and cost effectiveness, so that they establish proper norms and standards and work measurement processes for improvement in utilisation of equipment, increase in production, reduction in investment costs and overall economy in construction/production costs. Continuous updating and review of information individually by them and by a Central Coordinating Agency to be established for the purpose, would help in improving the position. Unless the suggested process is a continuous one, periodical assessment at long intervals of time, will not help improve the position.

The Committee would like to record their appreciation and thanks to all the equipment users — the State Governments, Central Government Departments, Public Sector Undertakings and Private Organisations, who co-operated in the matter of rendering valuable data and information and made the task of the Committee easier for framing conclusive observations and recommendations. The Committee were provided with the opportunity of having access to all the information that was called for during the visits to the projects/worksites or through correspondence.

The Committee are highly grateful to Shri S. K. Jain, Chairman, CW&PC and Shri J. P. Naegamvala, Member (P&P), CW&PC, for the valuable advice and guidance given during discussions on important observations. Conclusive thinking in relation to certain subjects involving policy matters, organisational set up and practical problems in management, operation and utilisation of equipment was consequently made easier.

The Committee would like to record their appreciation of the assistance given by Shri T. R. Nayar, Deputy Chief Accounts Officer, Beas Project, Talwara, in finalising the details regarding accounting of ownership and operating costs of equipment, as given in Chapter 13 of the Report.

The Committee would also like to record their appreciation of the strenuous efforts and hard work put in by Shri M. C. Praharaj, Member-Secretary of the Committee in compilation and analysis of the data received, besides attending to the normal functions of organising the meetings of the Committee and processing the minutes etc. The magnitude of work was tremendous while the strength of staff, as provided, was so little. The assistance given by Shri O. P. Marwaha, Assistant Director in initial sampling and compilation of information and in preparation of the drafts of the appendices as well as processing of all the drafts documents upto the final stage of the report was exemplary. Shri Marwaha served meritoriously to control the entire office work.

The Committee was fortunate in having Shri U. Krishnamurthy, Personal Assistant and Shri Bishal Mani, Upper Division Clerk. They worked with great zeal and keen sense of devotion to duty. They proved undefatiguable in putting ungrudgingly the lot of overtime which was necessary for completing the work.

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SUMMARY OF RECOMMENDATIONS

I. PLANNING

PROJECT PLANNING.

1. Technical approval of a project estimate should be followed by finalisation of design details, financial estimates and scheduling of the programme of work itemwise and in an integrated manner. For this to be properly accomplished, there should be a time interval between the approval of a project estimate and the commencement of work. A minimum period of one year should be provided on this account. A very clear view be taken initially of properly coordinating and integrating all resources for planning and scheduling of work.

2. All technical details relating to work should be finalised in a thorough manner at the inception of the job. This should include job specification requirements individually for items of works involved, considering the climatic conditions—length of construction season or operational season, topography, characteristics of the materials to be handled.

3. The mode of execution of work—either departmentally or through private agencies, should be clearly decided upon in advance.

PLANT PLANNING.

4. The task of plant planning should be as detailed and meticulous as the project planning.

5. A master plan of borrow areas and haul roads be prepared initially treating this subject as important as the basic plant planning exercise, so that safety of operations and minimum cycle time of operations by motorised equipment on production job can be ensured.

6. Adequate provision should be made for the construction plant and facilities for execution of the work according to the planned/phased programmes, as scheduled.

7(a). The complexity and character of the work to be performed should be carefully considered, so that radical changes are not necessitated in the course of execution of work as it progresses.

(b) Selection of equipment, by type and numbers, should be based on economy in methods of work relative to job conditions and intensity of use, maintenance and repair costs, facilities required, standardisation etc., etc.

8. Scaling of requirements of equipment should be based on rational factors of availability and utilisation.

9. Provision of standby equipment, assemblies, sub-assemblies and components should also make an important consideration, both for determining the total quantum of equipment to be employed on the job and the facilities to be created for maintenance and repairs. The main guiding factor should, however, be least investment, optimum utilisation and maximum possible productivity of machines for economy in production cost.

10. On the plant planning exercise initially completed, a second opinion should be taken before the financial estimate is prepared.

11. Plant drawings should be prepared in proper details in designing the lay-out. As far as possible, these should be prepared on standard sized sheets properly titled, dated and numbered, to facilitate reference.

12. Design criteria and structure design calculations shall be recorded and preserved.

WORKSHOPS AND FACILITIES

13. Adequate provision should be made in the project cost estimate to meet the cost of workshops—buildings, equipment and facilities.

14. Initial planning of workshops at the stage of formulation of project reports should cover all details regarding items and types of work to be done, the maximum work load possible to arise in respect of each, the pattern of

सत्यमेव जयते

maintenance and repair of equipment whether centralised or an area maintenance basis or a combination of both, and the extent to which work will be got done by outside agencies and the amount of investment that can be made.

15. A clear plan should be developed of the lay out of the shops by listing out the type of repair work, servicing and maintenance operations to be assigned to shops commensurate with the number and type of machines, plant and equipment to be maintained and serviced, and the load of manufacturing activities. Further room for expansion and flexibility of operation inside the shops should be provided for.

16. The type and sizes of the workshop buildings should be decided upon with due consideration to climatic conditions, geographical location etc. Clear provision should be made for drainage facilities, parking spaces, storage of raw materials, equipment awaiting work in the shops, repaired equipment awaiting delivery to the users etc.

17. Adequate material handling facilities should be provided both inside the shops and the open space outside.

18. The location of the shops should be decided upon by preparing a clear plan of the operational activities which will be served thereby.

19. Size of the shop should be determined by the type of equipment, components, assemblies that will be put to repairs. Provision should also be made for storage of the components, parts and assemblies and for the fitters'/Workmen benches. There should be no congestion of the work space.

20. Properly laid service roads, stabilized shop floors to suit the type and size of the equipment that will move over it, should be provided.

21. The area maintenance shops should be located as near to the scene of operation as possible. Good access roads should be provided.

22. Creation of adequate facilities in advance for maintenance, repair, storage and care taking of the equipment in the interim period, between the time of its receipt and actual commissioning on the job, should be a prerequisite.

23. Plant equipment assembly yard should be provided for, as near as possible, to the main workshops for assembly and initial commissioning of all plant and equipment, except those which, by virtue of their type, size, mobility etc., have to be assembled/commissioned on the job as close as possible to the point of application.

STORES AND WAREHOUSES.

24. Store room and warehouse facilities should be located adjoining the maintenance shops.

25. Receiving areas in the warehouses should be provided separately with sufficient space to accommodate mechanical handling and loading and unloading operations.

26. Specific attention should be paid to provide a proper building for storage of tyres, tubes and other rubber materials.

27. Slow moving and heavy parts which are treated with preservatives, or on which weather has no adverse effect, should be stored in the open.

PROCUREMENT OF EQUIPMENT AND SPARE PARTS

28. The programme for procurement of equipment should be so planned that it would be physically available for production work on schedule. However, the time table should be so framed that the equipment does not have to lie idle for long for want of work.

29. Initial supply of spare parts, sufficient for running and maintenance of the machines for 2000 to 3000 working hours should be ensured. Procurement action should be suitably finalised for this to be so.

30. Supply of filters for maintenance of the machines should be arranged with the machine for a minimum 2000 hrs. work.

31. Information on scale of consumption of spare parts relative to the type, make and category of machine/s to be purchased, should be obtained from projects/departments where such equipment had been in use previously, unless such information is available otherwise. This should be used for a guide line for procurement of spare parts for initial supply.

32. The procurement of spare parts and provisioning should be done with due consideration to the population of equipment of one type, make and category, and its intensity of use, whether single shift or multi-shift operations.

II. OPERATION

SCHEDULES

33. In defining the annual schedules for operation of equipment, the effort should not be to scale down the figures because of certain persistent occurrences, which take away a part of the available working time; but instead corrective action should be planned for minimising such losses in time.

34. The working conditions should be under constant examination and review in order that the operational efficiency of the machine is not impaired.

35. Requisite conveniences and facilities which help promote efficiency of Operators, should be provided in a liberal manner.

36. Unless certain physical limitations come in the way of working the schedules of working hours should be framed on the basis of two shifts or 3 shifts per day.

UTILISATION

37. Utmost efforts should be made for optimum utilisation of equipment. However, maximum utilisation should not be taken as an index of maximum productivity of machines. Progressive review should be made of cycle time of operation of each type of equipment on the job, through organised 'time and methods studies' so that the delay factors are removed from the cycle time, the minimum possible and the production the maximum possible. This should set the level of utilisation expected from the machines.

The aim for level of utilisation should be set at a minimum of 70% of scheduled hours.

38. For improvement in utilisation of equipment, the defect analysis (the defects which account for down-time of equipment) should be made and corrective actions taken to reduce the incidence of breakdowns.

TRANSPORT AND COMMUNICATION SYSTEM

39. Meticulous attention should be paid to haul-road construction and maintenance. Sufficiently wide roads, with proper sub-grades, smooth surface—properly moist, easy gradients and easy curves and bends, should be provided for attaining safe maximum speeds by motorised equipment.

40. For excavating equipment, the borrow areas should be made even and clean with the use of proper equipment.

41. For convenience of expeditious communication, wire-less sets, radio net work, telephone lines etc., should be provided where motorised equipment is spread over a fairly wide expanse of area under operational activity.

III. MAINTENANCE

42. The work of maintenance of equipment should be assigned to a senior, qualified and experienced officer, who is fully acquainted with the machines to be maintained. The organisation under his charge should similarly include experienced and skilled hands.

Competent senior operators with long-standing experience in operation of the machines on the job, should be employed on maintenance work.

43. Unskilled labour strength should be brought to the minimum and inefficient maintenance staff removed from the maintenance activity based on proper evaluation of maintenance effectiveness (in terms of availability of equipment and cost incurred on maintenance).

44. A minimum number of brands and grades of greases and oils should be put to use for the lubrication of various machines at the site of work.

45. Maintenance charts be displayed at suitable locations in the maintenance area based on recommendations made in the operation and maintenance manuals relative to the machines in use.

46. Printed forms based on recommendations made in the manuals, stipulating the tasks to

be performed at defined intervals of time such as 50 hrs., 100 hrs., 200 hrs., 250 hrs., 500 hrs., 1000 hrs., etc., should be used for recording the maintenance activities performed.

47. Adequate facilities should be created for maintenance and repairs to equipment. Provision of hand-tools and other handling facilities, which would cut down the overall time in maintenance/repair of equipment should be provided.

PREVENTIVE MAINTENANCE

48. Preventive maintenance should be given the prime attention and the importance it deserves. The responsibility for preventive maintenance should be assigned exclusively to a senior officer.

RECORD KEEPING

49. Proper record keeping should be organised. This should be looked after by senior persons — engineers, and should not be left entirely to the clerical staff.

50. Compilation of performance data on production and costs, shall be made by creating proper records under the direct supervision of an engineer, so that corrective actions, if any necessary (based on analysis of the information so recorded), can be taken for improvement in utilisation, productivity and reduction in costs in various segments of work.

PROCEDURES

51. For effective control in execution of the maintenance work, a clear chart shall be prepared defining "Who", "What", "Where" and "How" of the maintenance activity to be performed.

52. Wherever the total spread of equipment and the number of machines to be maintained in a given span of time so warrant, mobile/field servicing/maintenance units should be provided.

TRAINING

53. Periodical refresher courses for the operators, mechanics and maintenance crews should be conducted and systematic training programme for the new recruits will be organised.

IV. REPAIRS

54. The work in the main repair shops should be sub-divided according to the functional requirements so as to accomplish concurrent repairs of components and assemblies for expeditious completion of the repair of any given machine.

55. Where major repairs are to be carried out at the site of work, functionally designed mobile repair shops mounted on trucks and equipped with full complement of tools etc., should be provided.

56(a). In the process of repairs to equipment, the disassembling and reassembling of the parts/components from sub-assemblies, main-assemblies and the machine should be done according to instructions given in the shop manuals for the particular item of equipment under repairs.

A blue-print showing the important measurements, fits and tolerances to be observed in reassembling of parts/components in sub-assemblies, and main assemblies should be prepared and displayed at suitable locations, in the repair shops for reference by the repair crew, the Chargemen and the Foremen inspecting the work.

(b) Printed Check Lists, listing items of check at stage inspections by supervisors, should be used. These should be recorded in the History Book of the machine/assembly/sub-assembly etc.

(c) Observations should be recorded after inspection of the machine/assemblies/sub-assemblies at the time of overaul of machines and comparative study made with similar observations made on inspection of the machine at the time of preceding overhaul.

(d) Such record should be created and maintained by competent hands of the rank of Foreman/Assistant Foreman and should be continually reviewed by the engineer in charge.

(e) Special notice be taken of repetitive type breakdowns and premature wear on components indicated by analysis of information in the Inspection Sheets and corrective actions taken to reduce the incidence in future.

(f) Cost of repairs should be evaluated and recorded after every repair/overhaul; and this should also be subjected to regular reviews at periodical intervals, from standpoint of economy.

सत्यमेव जयते

(g) Arrangements for testing of individual assemblies and sub-assemblies after repair and overhaul should be organised where the volume of work involved is heavy.

(h) Tests and trials of repaired equipment should be assigned to a competent hand and all necessary adjustments in various systems of the machines properly made before the equipment is recommissioned on the job.

(i) Only skilled, qualified and trained persons should be assigned the repair work. The unskilled labour should be employed for handling work only.

V. SPARE PARTS

INDENTING.

57. Indents/Requisitions for procurement of spare parts should be prepared by experienced engineers who are well acquainted with the technical design and construction features of the machines, their operation, maintenance and repair.

58. Scaling of requirement should be based upon the record of consumption in the past, the history of performance of machine/s, the immediate requirements based on observations after inspection regarding wear and tear of the parts and components etc., and the period of time—stage in the age of the machine; for which the spare parts would be required.

59. For indents to be processed through DGS & D, a clear scrutiny be made of the questionnaire in the Check List to make sure that all the information has been included/given properly in the prescribed indent form to avoid any back reference from the DGS & D.

PROCUREMENT

60(a). To ensure timely availability of required spare parts, forward planning should be done with due consideration to the lead time involved in procurement—the total time from the stage of framing of the requisition to the point of physical delivery of the spare parts in the stores.

(b) Processing of requisitions/indents for procurement should be done at regular intervals of time—preferably on half-yearly basis.

(c) In processing the indents/requisitions, details of items and quantities on order and the stock position in respect of each, should be first checked up and accounted for and procurement action then taken for the balance items/quantities.

(d) For procurement against DGS & D Rate Contracts, proper evaluation should be made initially of the items that shall have to be imported by the supplier, so that delivery schedules can be suitably fixed and necessary arrangements made for obtaining the Actual Users' Import Licence in case the import is not against the suppliers' own licence.

(e) For time bound programmes of construction work, the project estimates should indicate the cost of spare parts which will be purchased in the service life of the machines thereon.

(f) Annual budget estimates should be framed for purchase of spare parts covering requirements of the period corresponding to the lead time of procurement.

RATE CONTRACTS

61(a). The DGS & D may examine the reasons why the Rate Contract holders cannot stick to the delivery schedules, furnish price-lists of goods ordered against rate contracts and expedite finalisation of rate contracts.

(b) In verifying the competence of any firm in respect of rate contracts for indigenous items, a more meticulous check may be exercised in identifying the established facilities, technical know-how on part of the manufacturing concerns, the research, development and design set up available with them, and the goods being actually manufactured by them at the time of the new items of spare parts are planned for manufacture by them.

(c) The DGS & D may consider to introduce a system of review of performance of rate contracts based on annual drawals. If the value of such drawls is below a certain expected minimum, the reasons for such performance may be gone into; and, if necessary, continuance or otherwise of the rate contract in operation should be examined, in case the reasons indicate any serious drawbacks in the quality of goods, service of the rate contract holder etc., etc.

(d) The consignee's copy of the invoice or despatch note should include the unit price and the total value against each item covered therein.

INVENTORY CONTROL

62(a). Each major user of equipment should establish a scientific inventory control system. A separate Cell should be created for effective implementation thereof.

(b) Scale of consumption of items of spare parts other materials should be developed and established for guidance of the indenting departments.

(c) For convenience of inter-departmental and intra-departmental coordination in matters relating to equipment and specially that relating to exchange of information on availability of spare parts for different items of equipment, a codified list should be developed for classifying like items of equipment for preparation of inventories of spare parts atleast for high value items.

SCALE OF PROVISION

63(a). Based on the guide lines given in Appendix 8.7 a scale of provision (by value) of spare parts for given types, makes and categories of machines should be lined out taking into account the intensity of use of equipment and the job severity factors.

(b) Until such time there is larger population of indigenous equipment in the country and the imported equipment ages out to the point of its replacement by indigenous equipment, liberal sanction of foreign exchange be issued for importing maintenance and repair parts.

OBSOLESCENCE

64. In framing a value estimate for the total cost of spare parts for the service life of the equipment on the job, provision should be made upto 5-7% of the value figure towards likely cost of obsolete/dead stock items of spare parts which may not find any use or resale ultimately.

This provision should also be taken into account in evaluating the inventory holding costs for purposes of determining the issue rates. wherever this system is in use.

REVIEW OF INVENTORY OF SPARE PARTS.

65. Perpetual review of inventory of spare parts should be made a normal feature of the work with the stores organisation. Action to discard items which are physically deteriorated and useless, and disposing of items which are surplus to the requirements, should be taken after such review.

FOREIGN EXCHANGE

66. Timely arrangements should be made by the sponsoring authorities for foreign exchange allocations so that import of spare parts is not delayed on this account.

The users of equipment should ensure timely processing of import licence applications, completing these in a satisfactory manner so as to avoid back references from the application processing authorities.

67. Value limit for import of spare parts against emergency licence should be increased from 0.1% to 1% of value of equipment.

MANUALS/CATALOGUES OF SPARE PARTS.

68(a). Care should be taken to have a master record of all spare parts catalogues at a central place for all makes and models of machines/plant in use. Besides the central holdng, the spare parts catalogues should also be available with each Division/sub-Division in charge of the items of machines.

(b) Arrangements should be made with the suppliers of equipment/manufacturers to supply copies of bulletins/service sheets indicating changes in part numbers or additions and alterations in the original parts catalogues in relation to particular makes and models of machines. Copies of manuals/catalogues should be complete and kept updated all the time.

VI. ACCOUNTING

ITEMISED COSTS

69(a). To simplify the procedure of accounting, a list should be developed giving Code Numbers for the items of expenditure in relation to ownership and operating costs of machines. To develop such a list for the benefit of those who are not already using the system, help should be taken from the management institutes in the country.

(b) The items of expenditure should be properly identified so that accounting thereof helps directly in estimation of costs of future works, evaluating the actual costs for purposes of job control and subsequent estimation, and provides necessary data and analysis relative to subject of 'Equipment Economics'.

COST EVALUATION.

70(a). Grouping of items of expenditure should be so arranged that it facilitates, assessment of the unit cost of work and a comparative study of the estimated cost and actual cost not only of the work as a whole, but of the individual items of cost also.

(b) Figures of annual expenditure and cumulative expenditure (1) maintenance and repairs and (2) depreciation cost, for a machine/group of machines of the same make and model, should be readily available through accounts records.

METHOD OF ACCOUNTING.

71. With the exception of depreciation which should be accounted for as an item of ownership cost, all other elements of the cost of machines should be treated as operating costs or running and maintenance costs.

72. Repair costs should be classified under one head only without making a distinction between field repairs/running repairs/minor repairs and major repairs.

73. To gauge more accurately the costs of repairs to the machine, the machine should be broken up into systems/components—power unit, clutch, transmission, final drive, crawler tracks, etc. The intensity of wear and tear on parts, in individual components/systems, can be sized up better by such analysis.

74. Depreciation costs should be accounted for annually based on 'Declining Balance Method of Depreciation'. The life of equipment for depreciation purposes should be fixed in number of years and the rate of depreciation should be selected commensurate with the pattern of work in one shift, two shifts, or three shifts per day.

75(a). The item of 'Spare Parts' should be distinctly identified by a proper classification in a separate sub-head under head 'Stock Suspense'.

Reserve limits for stocks should be defined on annual basis at the beginning of each accounting year.

(b) For commercial undertakings and public enterprises, spare parts should be classified under a separate head distinct from general stock items.

76. There should be no arbitrary shifting of costs from items showing cost over-runs to items showing cost under-runs, to present apparent balance with 'Control Estimate.'

77. Arbitrary advance lump sum distribution of expenses, which tend to minimise accounting efforts, but distort current cost accounts by over-writing the cost of items not yet used on works, or to reckon amount of expenditure on notional basis, should be avoided.

78. Meticulous care should be taken to maintain proper records in relation to costs, consumption of POL and materials and expenditure on labour.

Preparation of the record and analysis of costs should be done by competent hands and in time. Delay in accounting for the cost at different levels, would always give a distorted picture hence, promptness should be ensured in accordance with a predetermined time-table.

HIRE CHARGES.

79. To safeguard against the burden of idle depreciation due to machines lying idle for certain periods without being given on rent, practice as indicated in Chapter 9 should be adopted to provide for the additional charges.

80. There should be uniformity in the basis of assessment of rental rates or hire charges of earthmoving machines and construction equipment.

81. Straight-line Method of Depreciation should be adopted for calculating the hire charges. No salvage value is to be considered in such cases.

82. To safeguard against idle depreciation due to under-utilisation of machines given on hire, basic minimum charges for defined periods of loan of equipment should be fixed.

VII. TRAINING

83. Enrolment of trained operators and mechanics for operation, maintenance and repair of equipment, should be pre-arranged, so that the machines are not assigned to unskilled hands or those do not have to wait idle for want of skilled personnel.

84. In-service-training programmes for training of maintenance and repair crew should be organised.

85. Uniformity should be introduced in the syllabi of training in all training establishments and institutions.

Recruitment of trainees for operators and mechanics should be made from amongst the I.T.I. qualified personnel, or Diploma holders in Mechanical Engineering.

86. A Governing Body be constituted, comprised of representatives, one each from the Mining Sector, Irrigation and Power Sector, the rest of the users of equipment, Planning Commission, Directorate General of Employment and Training (Ministry of Labour, Employment and Rehabilitation) for formulating and directing the training programmes of the training establishments and institutions.

87. In order to make the project/States authorities in the Irrigation and Power Sector partners with the CW&PC/Ministry of Irrigation and Power, in the matter of organising the training programmes, provision should be made in the project estimates from one-fourth of one per cent to one-half of one per cent, of the estimated cost of the project, for training purposes. 50% of this provision could be used for in-service-training on the project and the balance could provide funds for contribution to the Technical Training Centres for training the sponsored nominees of the projects/States.

88. The Training Centres should be manned by persons of the rank of Joint Directors and engineers, assisted further by skilled Foremen and Mechanics.

89. The Equipment and facilities in the existing Technical Training Centres of the CW & PC should be suitably remodelled so as to have equipment of more recent origin, the like of which is currently in use on projects. The method of training should be suitably reoriented by introducing short-term courses (of 3 months' duration) for operators' training (Specialised Operator for individual categories of machines) and long-term courses (of 12-15 months' duration) for training mechanics.

90. The personnel supervising the operations of equipment should be suitably trained. The training of the executives should be such as to make them clearly understand the functions of planning, execution and review, in relation to specific positions held by them. The Foremen, Chargemen, Supervisors and Overseers should also be similarly trained so that the 'How', and 'Why' of a job can be clearly understood by them.

91. Senior officers managing equipment operations and utilisation shall be trained in net work techniques so that planning and scheduling of construction programmes and operations and utilisation of equipment could be properly achieved.

92. Supervisors and executive officers should be deputed by various organisations making intensive use of construction plant and equipment for training in "Construction Plant Planning, Administration and Maintenance" on major projects in the country. This training shall be on the same lines as was programmed in the past under the US AID Participants' Programme of training in U.S.A.

For this purpose, about six major projects where the work is being performed efficiently (this will include irrigation and power projects, mining projects and road construction projects) should be identified from time to time and the list circulated to all major users of equipment (Central/State Government Departments, commercial undertakings and public enterprises etc.).

93. The syllabi prescribed for Engineering Courses in the Technical Institutes and Universities should additionally cover the following subjects:—

a. Construction methods and techniques.

b. Selection of equipment for given job applications.

c. Planning of equipment for better production and economy in end cost.

d. Maintenance Engineering.

e. Equipment Economics.

VIII. STANDARDISATION

94. The term "Standardisation" should be given the required amount of importance it deserves. The economy resulting from standardisation should be properly evaluated not only relative to the selection of equipment for its first purchase, but also to all other aspects which get involved in management, operation and utilisation of machines.

95. A clear policy about the makes and sizes of machines in different categories and makes of their power units should be laid down at the time of first bulk purchase of equipment for the project in the event of procurement in stages.

96. Bulk purchase of equipment of new makes should be resorted to only after (i) proper tests and trials are conducted initially on these machines by importing a small number into the country; and (ii) the technical modifications on the design and construction features that may be indicated by the tests, are properly carried out.

IX. COORDINATION

97. For proper management of construction plant and equipment working on a number of projects, in a State, in a sector, or in a given public enterprise, a central organisation/coordinating agency be established for pooling and controlling the resources and to collect, compile and disseminate important information on equipment, with a view to promoting higher standard of efficiency and better utilisation.

For this to be achieved, these coordinating agencies be actively associated with the functions of, planning the overall requirement of construction plant and machinery; procurement of machinery; introducing inventory control methods; creating a proper record of census of machinery; history of performance; cost evaluation; norms and standards of production by equipment; consumption of materials; planning for major repairs and reconditioning of equipment; transfer of machinery from one project to another within the organisation or outside; establishing liaison and coordination with other coordinating agencies in different departments/sectors in the matter of record of performance of equipment; scale of consumption of parts, methods of work with machines, recruitment and training of operating and maintenance staff etc.

98(a) A Standing Committee for Equipment Planning be constituted under the aegis of the Ministry of Irrigation and Power with representatives of major users of construction plant and equipment in the country as members, to coordinate with Departments/Ministries concerned with important matters of common interest, such as import substitution, indigenous manufacture of equipment and spare parts, Import Trade Control policy and procedures, procurement/purchase of equipment and spare parts, etc.

The Committee shall function as an associate technical body for the Plant Planning Committees of major projects/sectors making large scale use of construction plant and equipment.

The Committee shall review periodically, the performance data of equipment, norms and standards for life of equipment, maintenance and repair costs and other cost elements for study of Equipment Economics, and framing equipment replacement policies.

(b) For the function of plant planning, the Plant Planning Directorate of CW&PC will be represented on the Committee and will provide the secretariat service.

(c) For the function of data evaluation and cost evaluation etc., and for other matters of common interest to all users of equipment, the Coordination Cell of the CW & PC will provide necessary assistance to the Committee.

99. In the Irrigation and Power Sector, the States where the Central Mechanical Units have not been established, or where these are operating as nucleus organisations, should take necessary steps to establish fulfledged units at the earliest.

100. In order that the Central Mechnical Units perform the assigned functions in an effective manner, considering the amount of equipment working in individual States as at present (barring a few), the officer/s manning the

सत्यमेव जयते

Central Mechanical Units in major States should be of the rank of "Chief Engineer". The functional distribution of work would generally be on the pattern given in Appendix 12.5.

101. To provide a proper forum for exchange of views on part of major users of equipment in various sectors, on important matters relating to equipment selection, operation, maintenance, utilisation, cost evaluation etc. Equipment Seminars should be organised on annual basis by the Equipment Planning Committee.

X. DISPOSAL/REHABILITATION OF SURPLUS EQUIPMENT AND SPARE PARTS

102. Equipment should not be retained longer than necessary on projects/works. Advance planning should be made for rehabilitation/disposal of surplus equipment.

103. The Central Coordinating Agency for a State in a sector, or in an Undertaking, should be assigned the work of rehabilitation/disposal of surplus equipment. Prior clearance should be taken from this Coordinating Agency regarding non-availability of the required items before these are purchased from the open market.

XI. IMPORT SUBSTITUTION

EQUIPMENT.

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104. The manufacturers should augment the manufacturing programmes under execution or projected to be executed, so that imports of the machines covered by the programme do not become inevitable.

105. To give an impetus to import substitution, timely forecast of requirements of equipment by the needy users in the country is necessary. They should help the equipment manufacturers by placing their indents of equipment on them at least 12 to 18 months in advance of the actual requirement on the job.

106. In relation to inevitable imports of equipment resulting from imbalance between demand and supply, specially when emergent/urgent requirements of equipment arise, it should be the policy to import equipment which is similar or identical to the equipment being manufactured in the country. This will help at least in conserving a part of the foreign exchange required to import subsequently the spare parts etc., for maintenance and repair of equipment.

107(a) The manufacturers and the users of equipment should co-ordinate with each other in enhancing the scope of manufacture, by identifying additional items of machines for which the generated potential of demand is substantial.

(b) The Standing Committee on Equipment Planning (defined at 99(a)—Coordination) should be the liaison agency for all major users of equipment and the manufacturers for market survey to determine the potential of requirement of new items of machines.

SPARE PARTS.

108. To promote import substitution in respect of spare parts, the Co-ordinating Agencies in various Sectors/with various organisations, should work together in identifying the particular items which do not involve complex processes of production—technically or metallurgy-wise and for which the potential of requirement is substantial for economy in production costs.

109. Until such time a major portion of the available imported equipment in use in the country is discarded from operational activity, annual sanctions of foreign exchange for import of spare parts for equipment should be sustained at adequate level.

110(a) The DGTD, the DGS & D and the Coordination Cell in CW & PC should work together in identifying the manufacturers who would undertake the manufacture of defined items of spare parts identified for import substitution.

(b) Similar effort should be made by the major users of equipment and their Central Coordinating Agencies to which they are affiliated.

111(a) While planning the manufacture of spare parts on private firms, a clear evaluation be done of the resources, facilities, technical know-how and the experience on their part so that the resultant product is of standard quality acceptable to all.

(b) Even if in some cases, working drawings and specifications of the items to be manufactured are to be obtained from the primary manufacturers abroad on payment, this should be arranged, provided the potential of requirement is large enough to warrant such payment.

INDIGENOUS MANUFACTURE—EQUIPMENT.

112. Unless the items of equipment selected for manufacture are those, which have been previously in use in the country and whose performance has been found to be satisfactory, a prototype should be imported for rigorous tests and trials for technically evaluating its standard of performance before it is accepted for manufacture in the country. Such selection of equipment for indigenous manufacture may be done in association with the Standing Committee for Equipment Planning.

113. For optimum utilisation of equipment within the very first two years of its commissioning on the job, adequate supply of spare parts should be ensured by the indigenous manufacturers. Since this will also involve imported items of spare parts, restrictions on the import of such parts for initial supply with the machines should be relaxed as far as possible, unless the indigenous sources are clearly identified to have been properly established and in production by the manufacturers or by the ancillary industry.

INDIGENOUS MANUFACTURE—SPARE PARTS.

114. The spare parts catalogues should clearly identify either the imported items or indigenous items to facilitate expeditious processing of indents/orders for spare parts.

115. The service organisations of the manufacturers should develop a system of collection of information from the users of their equipment regarding scale of consumption of atleast high value items of spare parts, commensurate with the size of fleet of equipment in operation at individual locations to afford guidance in sizing up the indents of spare parts on forward planning basis in a more precise manner.

AFTER-SALES-SERVICE.

116. The manufacturers of equipment, through their service organisations, should organise dispensing of spare parts on 'stock and sale' basis. This alone will help in reducing the size of the inventory of spare parts for indigenous equipment with individual users and thereby curtail the amount of investment blocked up in slow moving items in the inventory.

They should establish a scientific inventory control system for sizing up the inventory of spare parts for stocking purposes.

117. The service organisations of the equipment manufacturers should be properly developed to help the users of equipment to sort out their problems with respect to operation and utilisation of equipment.

RESEARCH AND DEVELOPMENT.

118. The manufacturers should evolve an effective system for 'feed-back' of information relating to performance of equipment, assemblies, sub-assemblies, components and parts. They should establish close liaison between the service organisation and production department through the Research and Development Section.

119. The research and development organisation of the manufacturers of indigenous equipment, besides making research for improvements in the design/system of the machines based on experience of the equipment users in the field, should also make a continuous advancement in the technical front to make the machines more productive at lesser maintenance and repair costs.

XII. MANAGEMENT

ORGANISATION.

120. Management of operation, maintenance and utilisation of equipment should be so organised that the planning and execution of work is a smooth and coordinated process for effective control on production and economy in cost. The organisation should be well-knit for a coordinated effort and frictionless working amongst all levels of management on the job.

121. For proper management, operation and utilisation of equipment, the functional control on operation, servicing, repair etc., of equipment shall be assigned to one suitable organisation only on unitary control basis, under an Equipment Manager.

122. An efficient maintenance materials management organisation should form a vital part in the whole organisation so that equipment is not laid off in absence of some vital supply of parts etc.

123. The size of the organisation and the type of administrative control (defining the line of heirarchy) shall be determined by the size of the fleet of equipment value-wise.

124. For functional control of large-sized fleets of equipment concentrated at single locations, the distribution of work will be so made that specialisation and economy in investment costs can be achieved basides ensuring least expenditure in repairs and better quality of repair and maintenance work.

IMPROVEMENT METHODS.

125. For evolving methods of improvement in operation, utilisation and productivity of machines, a separate Cell for carrying out 'Time and Methods' studies should be orgainsed by every large scale user of equipment well in advance.

126. For proper planning and scheduling of works, use of 'CPM' and 'PERT' which make the modern methods of planning, should be extensively made.

127. The progress reporting system should be so laid down that review of performance is made for introducing improvements in operations and achieving cost effectiveness.

INCENTIVES.

128. Suitable incentive schemes be introduced for increase in production simultaneously ensuring the proper upkeep, maintenance and repair of equipment on sustained basis. The benefits of the incentive schemes should cover and accrue to every person who is a member of the team, contributing increments in production and safe, continuous and economic working of equipment.

129. Where the job is of large magnitude entailing employment of large fleet of equipment and heavy investment, use of computors/electronic data processing equipment should be considered.

To broaden the perspective and keep abreast with the latest trends in respect of construction jobs, plant and machinery in use, improved techniques of maintenance and operation in advanced countries, a joint team consisting of senior engineer-managers from the Irrigation and Power Sector, Mining Sector, principal manufacturers, should be sent abroad periodically.

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ADDENDA TO THE SUMMARY OF RECOMMENDATIONS

ADD the following after "......2000 hrs. work" in Recommendation No. 30, page 16:—

"in case of indigenous filters. For imported filters, the supply should correspond to 2 years' operation of machines—roughly 4000 hrs."

INSERT between recommendation No. 55 and 56(a) at page 19, under IV 'REPAIRS':

"Unit replacement or component assembly exchange system should be widely adopted to reduce down-time of equipment under repairs. Repairs of units/assemblies removed from the machines should be expeditiously done in workshops, so that these are available as standby units."

ADD the following as a separate recommendation at page 27, after Recommendation No. 93, under VII 'TRAINING':

"Suppliers of equipment should arrange to impart training in operation and maintenance of the equipment supplied by them to the staff at various levels at the projects. This should make a requisite stipulation in the Purchase Order."

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सत्यमेव जयते

Gist of some important Norms & Standards recommended as guidelines.

1. Annual Schedule for Equipment Utilisation

No. of shifts in operation	Total available time in hrs.	Availability factor	Actual available time in hrs. 2×3	Average No. of days/yrs. (8 months)	Schedule per yr. in hrs. 4×5	Average utilisation factor	Average utilisation per year in hr. 6×7
1	2	3	4	5	6	7	8
One Shift . . .	8	0.9	7.0	200	1400	0.85	1200
Two Shifts . . .	16	0.8	12.5	200	2500	0.80	2000
Three Shifts . .	24	0.7	16.5	200	3300	0.75	2500

Range of Schedule hours, depending on the working days (150 *days to* 250 *days*) *available in a year.*

Single Shift . .	1000 to 1700 hrs.
Double Shift .	1800 to 2800 hrs.
Three Shifts . .	2400 to 3600 hrs.

2. Equipment Life & Depreciation.

See Appendix 8.4.

3. Stand-by equipment and component.

Operating Conditions	Stand by equipment as a percentage of the actual Nos. of equipment required.	Stand by components as a percentage of the total cost of equipment.
a. Single Shift	10	5
b. Double Shift	15	7
c. Three Shifts	25	10

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4. Repair Shops.

(a) *Field Repair Shop*

The scale of provision for floor space may be generally estimated at 50 to 60 sq.ft. per machine (where the size of the machine is small), and 100 to 120 sq.ft. per machine (in respect of heavy earthmoving machinery items).

An equal uncovered floor area with concrete floor, is also additionally required to be provided in the field repair shop.

(b) *Main repair Shop*

The scale of provision for covered floor area would be estimated at 150 to 180 sq. ft. per machine for a total No. of machines to be serviced in the shop. The uncovered hard surface floor space in this case may be 2½ to 3 times the area of the covered floor space set aside for the machine.

The cost of the covered and uncovered floor space and the sheds to be provided for the field and main repair shops may be estimated at 1.5% to 2% of the total cost of Equipment to be serviced in the Shops.

5. Repair Personnel.

The provision of skilled men for maintenance and repairs may be at the rates of '3' men for every '4' machines for single shift work; '2' men for every '3' machines for two shifs' work; and '5' men for every '2' machines in 3 shifts' work.

The skilled men would include persons in the categories of:—

(1) Mechanics—Senior or Junior;

(2) Fitters;

(3) Electricians; and

(4) Oilers and Greasers.

These figures are for guidance purpose only. The actual requirement would, however, depend largely on the type of organisation created for maintenance and repairs of machines and the provisions made by way of standby components and equipment etc.

Requirement of personnel for supervision, which would include Foreman, Assistant Foreman, Chargeman etc., would be of the order of about 10% of the strength of repair and maintenance personnel.

The provision of unskilled persons for such jobs may be estimated at 10% of the skilled hands provided in the shops.

For emergency repairs an extra provision to the extent of 10% may be made requirement of staff.

Normally, the requirement of personnel for preventive maintenance work would be commensurate with the particular items of work, a team would be assigned to carry out. Adjustments regarding number of persons to be placed in the team would have to be done from within the overall provision.

6. Shop Equipment & Tools.

A provision of 4 to 6% of the cost of equipment should be made for the purchase and installation of shop equipment and tools.

7. Repair Provision.

See Appendices 8.4, 8.8 and 8.9 for evaluating spare part provisions. The labour charges could be estimated at 10% to 15% of the cost of spare parts.

8. Provisioning of Spare Parts.

The planning for procurements of spare parts should be done on the basis of two years' requirements in case of imported items and one year for indigenous items. The initial spare parts purchased with the machine should be allowed upto 20% in the case of imported machines of certain types, if put to 3 shifts use. Initial spare parts should be arranged to an extent of 10% even with indigenous equipment.

CHAPTER 1

APPRAISAL OF THE CONSTRUCTION PLANT AND EQUIPMENT IN THE COUNTRY

In the past two decades, the construction industry has made rapid strides towards mechanisation. There has been rapid technological progress in equipment development to meet the requirements of increasingly large and complex construction projects. Simultaneously, with the advance in technology in other industries engaged on production of minerals and metals etc., the need for higher production at internationally competitive prices has also led to automation/mechanisation. All this necessitates substantial investment in capital plant and machinery.

The expanding range of required skills necessary for the success of mechanised operations and automation and the need for economy in the end cost of products produced by the equipment have been the foremost problems facing the management.

The magnitude of the problems involved has substantially increased commensurate with the increase in population and variety of equipment in the country. In order to identify the problems precisely in relation to equipment in use on different operational activities, it would be necessary to start with an appraisal of the construction plant and equipment in the country and the level of investments made towards cost thereof. A review of the character of this collection and identification of the individual units would help determine the precise nature of problems. Accordingly, it may be only logical to start with the background and history of growth of equipment population in the country.

1.1. Background and History

The history of the construction plant and equipment in India could be easily divided into the preindependence period which reflected a very slow process of mechanisation and the period of rapid growth of this process thereafter.

1.1.1 *Preindependence Period*

The evolution of construction plant and equipment is just another product of the attempts of man to be a master of his environment and to shape it to his maximum benefits. Mechanised development in industry, communication, construction and agriculture has inevitably meant, advances in economic growth. All these dependent on moving the earth and mineral deposits from the surface of earth or below it and quite often from underneath the water in the rivers and in the ocean. The abundant resources in India though providing rich reserves of economic value, remained unexploited practically in the pre-indpendence days. Whatever exploitation was done remained at a slow pace. When planning commenced in proper earnest in thi direction, it was necessary to obtain help from outside sources in the shape of equipment, services of professionals and engineering specialists and other expert personnel which were not available domestically. All the same, import of such man power, finances and the required items of equipment into the country was done in a discreet and restricted manner and dependence was maintained on the country's own man power.

The country thus had only a few of the construction and mining equipment etc., in the pre-independence period. Specimens of exploratory equipment, handling equipment, excavation equipment, etc., etc., as then brought to India are still available in remote corners of the country to give a reminiscence of the past.

Organisation and means to undertake large scale activities related to construction of dams for water resources and land reclamation etc., etc., were developed in a co-ordinated manner over an extended period after independence. Inspite of the restraint sounded by the financial resources, which no doubt, did put a curb on such activities, to some extent and for some time, it has been possible to implement various schemes that were both technically and economically feasible. The element of time, however, being most important for the overall economic growth of the country, for which the rich reserves and resources were to play a very vital role (being essential to electrification and industrialisation, agricultural production, land reforms, mining production and communications, etc.), the colossal man power available in the country has had to be utilised judiciously only on such jobs as did not afford physical limitations for manual labour and recourse was taken to mechanisation in various other fields with a view to augmenting the pace of development of resources and other allied activities incidental to these fields.

1.1.2 *Post-Independence Period*

In the post-independence period, the native skill soon developed to a degree of specialisation in various fields to augment the development resources. In the process, however, certain limitations had to be faced in the matter of selective choice of equipment and tools to achieve the progress in development in various fields. The items of equipment—referred to as tools, as imported initially or acquired through Defence surplusses from various Depots in the country after the 2nd World War, did not facilitate the best choice of equipment relative to the works where these were to be employed.

1.1.3 *Present Situation*

Even subsequently, as is generally true of growing economy in a developing country, the scanty foreign exchange resources of the country necessitated import of equipment from limited sources abroad which furnished loans/credits/aid for development of the country. Gradually, however, with partial improvement in the country's own resources and better position on the economic front through somewhat growing foreign exchange reserves, selective choice of equipment could be made to some extent. As of present, the country has come to a pass where, with the progressive development of indigenous manufacture of such equipment in the country, and a far better position on the economic front vis-a-vis foreign exchange resources, it has been possible to make judicious selection of equipment for different operations in various fields based on proper exercise of plant planning and economy in the end cost of products.

1.1.4 *Trends in equipment design and applications*

The benefits which have accrued to various programmes on which intensive use of equipment has been made, from research and development of equipment, have been substantial. Some of the more significant developments include:

(1) substantial increase in available capacity, particularly in earthmoving units and installed plants and other mining equipment;

(2) greatly increased use of pneumatic tyred equipment;

(3) introduction of automatic controls for improving matching performance and minimising operator fatigue and possible human errors;

(4) greater portability of some items of equipment like mixing plants and other major units;

(5) multifunctioning machines which perform several jobs in a single pass—mainly in relation to road construction;

(6) reduction in base weight of hauling units, whereby payloads can be increased.

Such developments in basic equipment designs have resulted from the development of basic equipment components.

Even though the development in equipment designs and applications abroad have been very remarkable, for various reasons, the selection of equipment for application in different fields of work in the country has had to be made in a restricted manner mainly in view of the gradually developing experience and skill in the use of sophisticated equipment or modern machines; the slow pace of development of production in different fields where exploration and exploitation still finds a fair amount of overlap and finally due to the scanty reserves of foreign exchange which could be spared for investiment in procuring a comparatively smaller number of imported machines for distribution over a large number of projects where the work had to be done simultaneously. Another reason for not using the largest of the machines available abroad on similar jobs in India, is the possibility of some of the costly sophisticated machines being rendered idle for long periods of time in absence of some of the minor parts which have had necessarily to be imported from the country of origin of equipment, thus resulting in possible blockade of investment unproductively. On all considerations, there has been a judicious selection of the size and type of equipment for given job conditions, programmes and applications in various fields in the country.

The new projects that are now being planned—whether in the Irrigation and Power Sector in the mining sector, are meticulously designed for maximum economy in end cost of products to be produced by the machines; and it is being attempted to introduce the large sized machines of modern designs and high degree of sophistication. Yet, the ultimate salvation from engineering economy stand point, would lie in ready availability of such equipment in the future from indigenous sources. No wonder, at present even with the most modern machines in use in the country in different fields, the cost of the marketable products cannot stand easy competition with other producers of same commodities abroad. The comparatively lower labour costs in the country all the same partially compensate for such a handicap and still make certain marketable products fairly competitive in the world market.

1.2 Population of equipment

Stock taking of the equipment, as now available in the country, has been done by the Committee by requesting the users of equipment in various sectors to render the necessary information.

The principal users owning the equipment are identified as under:

1. Irrigation and Power Projects—construction of Dams, barrages, canals, hydro-electric Schemes, Thermal Power Plants, etc.
2. Mining Industry—including Iron Ore Mines, Coal Mines.
3. Minerals and Metals.
4. Road Building.
5. Land Reclamation and Agriculture.
6. Port Development; and
7. Industry in general (Material handling and processing equipment).

1.2.1 *Information Rendered by the Users*

The information as rendered by the users of equipment in the country has been abstracted and placed at Appendix 1.1.

Based on the information given by the users, equipment worth Rs. 3000 million approximately is available in the country in various fields of application in different sectors. The figure indicates the actual purchase cost. By number, the census shows the figures at 16000 pieces approximately in major categories.

Due to inadequate record keeping by the users, as brought out later in the report, the information given with respect to value and number of machines may not be exact and one could expect substantial deficiencies and discrepancies. The Committee would, therefore, like to qualify the accuracy of the information by the insufficiency to the extent and the manner in which this has been furnished by the users.

1.2.2 *Information as Rendered by Dealers*

An attempt was also made by the Committee to secure information from the accredited agents/distributors of foreign principals in India, dealers and suppliers of equipment and other established importers of equipment, so that this could be compared with the statistical information obtained from the users and discrepancies located to the extent possible, in respect of the total figures and value of equipment available in the country. The information as rendered by the dealers is at Appendix 1.2.

In the past varying figures of value of such equipment have been given by the dealers, ranging from Rs. 2500 million to Rs. 4000 million. Even now, one single organisation —Tractor and Earthmoving and Construction Equipment Distributors' Association, which represents 14 principal equipment dealers in the country, have reported that the c.i.f. value of the equipment available in the country is Rs. 3600 million.

1.2.3 *Reasons for variation in Figures of Population as supplied by Users and as Rendered by the Dealers.*

The difference in the two figures of value of equipment available in the country—one based on the information given by the users of equipment and the other as reported by the suppliers/dealers of equipment based on the supplies made by them in the past 15 to 20 years, is mainly due to the following reasons:—

1.2.3.1 *Effect of devaluation*

The suppliers have taken into account the effect of devaluation on the sale price of the machines supplied in the country prior to the devaluation of the Indian Rupee, whereas the users of equipment have not taken this into account in the figures of purchase value of machines reported to be available. If the comparison is to be made on "present worth" basis, the difference will be narrowed down.

1.2.3.2 *Information not received from a part of the users.*

The figure of value of equipment as reported to be available with the users is based on the returns filed by particular users only. It is likely that similar equipment,—specially in the class of material handling equipment, like Cranes etc., would also be available in the private sector—industrial concerns. The difference in value may partially be accounted for by such equipment not included in the compilation.

1.2.3.3 *Part of equipment out of circulation*

Some of the machines or equipment otherwise accounted for in the total value of equipment supplied by the dealers, may be out of circulation, being no longer in use and therefore extinct. The users at their end may not have reported such items to be on their lists of available equipment. The value of such extinct equipment may have, therefore, to be discounted from the total value figures reported by the suppliers/dealers.

1.2.4 *Assessment by the Committee*

Based on a general assessment of the information received from the users of equipment and the suppliers/dealers of equipment in the country, the value of construction plant and equipment in use in the country and its population at the end of 1970, may be approximately reckoned at Rs. 3500 million and 20,000 numbers, respectively. The Committee considers that for future reference, only these figures be reckoned with.

1.2.5 *The Value of Equipment added year after year*

The value of equipment added year after year, as compiled from the data received is at Appendix 1.11.

1.2.6 *Value of new equipment added in 5 Years' Period from* 1956-1970

The figures are as follows:—

S.No.	Period	Value of equipment added (Rupees in lakhs)
1.	1956-1960	3600
2.	1961-1965	10000
3.	1966-1970	13000

It may be seen that major additions of equipment have been made in the last decade during the years 1961 to 1970. The additions during this period were almost 80% of the total.

From the year 1963 onwards, equipment worth over Rs. 20 crores has been added each year upto the year 1970—in some years, the figures have touched Rs. 24 crores to Rs. 37 crores annually. For the nine years from 1960 to 1969, the average number of machines added annually was over 1100.

Prior to the year 1956, the additions were less than Rs. 100 lakhs a year, except during the years 1953 and 1955 when these were of the order of Rs. 207 lakhs and Rs. 146 lakhs approximately.

1.3 Sector-wise Distribution of Equipment

The census of equipment reveals that the major owners of equipment in the country are the Government/Public Sector Departments. It was, therefore, considered desirable to evaluate the distribution of equipment in different sectors i.e., various Government Departments and agencies and the private sector.

The distribution in various sectors is detailed in Appendices 1.3 to 1.7, the value and number of the equipment in use with different sectors being:

S. No.	Sector	Appendix No.	Available equipment	
			Value in Rs. lakhs	Numbers.
1.	State Government Departments (including I&P)	1.3	13271.38	7542
2.	Central Government Departments (including I&P)	1.4	4455.72	3788
3.	Government bodies/Corporations/Public Sector Undertakings	1.5	8778.73	2897
4.	Private bodies	1.6	2651.79	1438
5.	I&P Sector alone	1.7	13924.85	7474

In terms of value of equipment in use in particular sectors, the Irrigation and Power Sector is the largest single Sector having about 35% of the equipment available in the country. Moreover, timewise also this Sector has had the maximum experience in the use of heavy construction plant and equipment. Large scale mechanisation of construction work on multipurpose projects, Hydro-Electric Schemes and Irrigation Projects, commenced immediately after independence. This sector has largely helped in training the man power on such equipment and such trained hands have been deployed on machines in various other Sectors, where use of such equipment started from the mid-50's.

1.4. Categories and Makes of Equipment

The broad categories of items of construction plant and equipment in use in the country are as follows:—

1. Exploratory equipment.
2. Power Generation equipment.
3. Earthmoving equipment.
4. Tunnelling equipment.
5. Quarrying equipment.
6. Crushing, Screening and Processing Plants.
7. Concreting equipment.
8. Road Building Equipment.
9. Transport & Material handling equipment.
10. Compressed air equipment.
11. Miscellaneous equipment.

The equipment in use includes, besides items of Indian origin, the machines imported mainly from the following countries: U.S.A., U.K., West European Countries, East European Countries, Russia, Japan, Canada, Australia, Sweden, Belgium etc. A majority of the imported equipment, however, is of U.S. origin.

1.5 Assortment of Makes and Models of Equipment

The equipment as now available in the country represents a galaxy of assorted makes of machines of different origins and a large assortment of the categories thereof. While the reasons for such a position being allowed to arise are being discussed in the later portion of this Chapter, the point regarding multiplicity of makes in each category of equipment is being illustrated in what follows.

1.5.1 *Multiplicity of Makes of Each Category*

For this purpose, the Committee have taken up only the principal categories listed hereafter, which account for over 85% of the value of the total equipment.

1.5.1.1 *Power Shovels and Cranes (including Draglines, Bucketwheel Excavators, Mucking Machines and Dredgers, etc.*

The principal makes of these machines in use in the country are as follows:—

American, Austin-Western, Brisco, Bucyrus Erie, Clyde, Coles, Demag, Drottskid, Eimco, Federal, Fowler, Goodman, International Harvester, Hind Marion, Jones, Lima, Link Belt Speeder, Lorain, Manitowac, Marion, North-West, Osgood, P&H, Polish, Priesman, Quickway, Ransom & Rapier, Rumanian, Russian, Ruston-Bucyrus, Skoda, Super, Tata P&H, Unikop, Washington. Besides these 35 defined makes of machines in this category, there is still a larger variety of makes, specially in respect of Cranes, which are of German, French, Polish and British origin.

Of recent times, however, the population of machines in this category, of Indian origin has been substantially increasing. Nearly 700 machines of Indian origin have been put to use in the country in the past decade. These are chiefly in the class of Power Shovels, Draglines, Cranes, etc.

It may not be necessary to give further details about the size of the machines in use which vary in relation to Excavators from 3/8th cu. yd. bucket capacity to 35 cu. yds. bucket capacity machines. The combination of sizes and makes would illustrate the complexity of the combination of machines to be properly looked after.

The largest population of machines in this category is that of P&H/Tata P&H Make.

1.5.1.2 *Tractors and front end loaders—Crawler mounted and wheeled*

The principal makes of these machines in use in the country are as follows:—

Allischalmer, Catepillar, Dutra (Hungarian), Eimco, Euclid, Fiat, Fowler Marshal, International-Harvester, Hanomag, Komatsu, Michigan, Oliver Cletrac, Richard Continental, Russian, Tigar, Track Marshal, Yugoslavian.

Besides the large number of makes of Tractors as above, it is noteworthy that in most of the popular makes, there are 6 to 8 models of each make in use in the country. This is mainly true of Allischalmer, Caterpillar and International Harvester Make Tractors of U.S. origin, and Komatsu make Tractors of Japanese origin.

The population of Tractors as an item of construction plant and equipment (Heavy Earthmoving Machines) singly accounts for about 1/3rd of the total population of machines of all categories in the country (excluding the item of Air-compressors). In addition, the large number of Agricultural Tractors (Wheeled), in use in the country, have been excluded from consideration in this case.

The largest population of machines in this category is that of "Caterpillar" Make.

1.5.1.3 *Dumpers (Off-the-Highway type)*

The makes of Dumpers in use in the country are as follows:—

Aveling-Barford, Balmer-Lawrie, Caterpillar/Caterpillar-Athey, Euclid, Foden Internation-Harvester, Koehring, LeTourneau, Le Tourneau-Westinghouse, Leyland, Mack, Mogurt, Muirhill, Perlini, Reo, Russian, Scammel, Sudwerke, Sterling, Tatra, Terracobra, Terex, Titano, WABCO.

In addition to the 24 makes of Dumpers in the 'OFF-THE-HIGHWAY-TYPE', as indicated above, the equipment owners have added large fleets of Tata Dumpers, Bedford Dumpers, Leyland Dumpers, all of indigenous make. These are generally for 'Highway' application; but with properly maintained haulroads, most of the contractors and mineowners have taken to the use of such Dumpers for 'Off-the-Highway' application.

During the last five years, the indigenous manufacture of Dumpers has tried to catch up well to meet the requirements of the users in different sectors. 'WABCO' Dumpers and 'Terex' Dumpers (in lieu of the old Euclid Dumpers), have started being produced in the country.

The largest population of Dumpers in the country is that of 'Euclid' make.

As in the case of the previous two categories of equipment, in case of Dumpers also, the range by weight of payload capacity of the Dumpers is very wide—it covers 7-T payload capacity to 72-T payload capacity.

1.5.1.4 *Scrapers (motorised and towed)*

The principal makes of equipment in this category of equipment in the country are as follows:—

Allischalmer, Birtley, Blowknox, Carryall, Caterpillar, Euclid, Hindustan, International Harvester, LaPlant-Choate, LeTourneau Westinghouse, Onion, Russian. Terracobra, Wooldrige, WABCO.

Size-wise, the range covered is 7 cu. yds. to 24 cu. yds. struck capacity.

In respect of Motorised Scrappers, indigeneous manufacture commenced over 6 years ago. M/s. BEML are the manufacturers in India, manufacturing LeTourneau Westinghouse/WABCO Make Scrapers.

In respect of Towed Scrapers, the manufacture thereof started over 7 years ago in the country. The Scrapers manufactured are 'Hindustan' Make.

The maximum population in this class of equipment is that of LeTourneau Westinghouse/WABCO Make.

1.5.1.5 *Motor graders*

The principal makes of equipment in this category in the country are as follows:—

Adams, Allischalmers, Austin-Western, Bristand, Caterpillar, Galion, Gradall, International Harvester, Huber-Warco, Russian and WABCO.

The population of Motor Grades in the country is rather small. Considering the overall population of equipment in the country in the earthmoving machinery class, the need for Motor Graders would certainly be more. Motor Graders are a very essential tool for the upkeep and maintenance of haulroads on construction jobs.

In special consideration of the road building programme, if mechanisation is resorted to, the extent it as is generally done in Highway construction in countries abroad, the requirement of Motor Graders in the country could be substantially more than the present off-take level.

Motor Graders of indigenous origin—WABCO Make, are now available in the country. However, the indigenous machine lies in the horse-power range of 115 only. For heavy earthmoving jobs, heavier duty Motor Graders are required.

1.5.2 *Factors Responsible for the Assortment*

The information covered by the preceding paragraph 1.5.1. reflects clearly the galaxy of assorted makes of equipment in individual major categories of machines. The question has often been raised, "Why cannot we standardise on equipment; and where is the need for so many makes to be put to use?" The question is aptly put, if the overall objective is better maintenance at least cost and optimum utilisation of equipment, besides scaling down of inventory of spare parts for such costly machines. The cost of the machines ranges from Rs. 1 lakh to Rs. 100 lakhs per machine or even more in some cases, specially for large capacity Face Shovels, Walking Draglines on coal Mining work and Bucket-wheel Excavators on Lignite Mining operations.

The following paragraphs indicate the main factors which have largely accounted for collection of a large variety of machines by makes and categories.

1.5.2.1 *Availability of foreign exchange*

Ready availability of foreign exchange from limited sources has most often made it imperative for equipment to be purchased from a particular country. Furthermore, the prescribed conditions relative to individual loans/ Credits/ Grants, have been of a nature as to restrict the purchase more often from a single country and to buy equipment against the cheapest tender. There have been cases where even at intervals of six months to one year, in respect of purchases made from a single country, different makes of machines of identical specifications had to be purchased. This entirely defeated the basic fundamental of 'Standardisation'.

In many cases, with progressive develpoment of work in certain fields, e.g., Coal Mining, Iron Ore mining, land reclamation etc., etc., import of equipment had to be made against loans/credits from different countries at different times, thus resulting in multiplicity of makes of equipment of different countries' origin on the same job.

In certain sectors, the work on individual projects having been financed under different foreign loans/credits, necessitated purchase of equipment from individual loan giving countries. Different projects were tied up with different countries; and hence, different items of equipment in the same category got collected at different locations.

The Government of India did constitute a Committee of Experts on Standardisation of Earthmoving Machines consistent with the recommendations made in the first Construction Plant & Machinery Committee Report. This Committee, however could not effectively progress due to constraints in the matter of selective choice of equipment arising from the scanty foreign exchange resources of the country and the prescribed conditions laid down by various loans/credit-giving authorities in respect of purchase of equipment against those loans and credits. If the principles and guide-lines laid down by the Committee of Experts on Standardisation of Earthmoving Machines had been followed, only a few machines of untried makes would have been brought to the country for tests and trials in the first instance, whereafter, the performance data, technical specifications and the construction design features etc., could have been wholly examined and evaluated by that Committee, and decisions properly taken as to whether the new makes of machines be included in the List of Standardisation framed by them, or its import in the country disallowed.

Considering these principles and guidelines, quite a few makes of equipment might not have found the approval of the said Committee and the equipment might not have been imported from certain sources. However, as already indicated in the preceding paragraph, such imports were considered inescapable if the commitments of work in certain areas had to be honoured and certain programmes executed in given time, but at a comparatively higher cost due to comparatively sub-standard performance of these machines,

1.5.2.2 *Purchase against lowest bid*

The normal financial rules regarding purchase of equipment etc., have generally warranted purchases against lowest bids. Even if those lowest bids were further classified as 'lowest technically acceptable bids', the selective choice of equipment was limited to the makes of equipment meeting the technical specification given in the Notice Inviting Tenders. The experience of various users of equipment in the country in respect of performance of particular makes and models of machines, was taken into account in very exceptional cases in making a preferential choice of one or the other make of the machines in the same category as offered by the tenderers.

1.5.2.3 *Plant planning based on inadequate date*

Most often, project estimates are framed mainly with a view to seeking necessary technical approval for commencement of the work on the project. At that stage, itemised technical details of individual items of work to be executed are not clearly spelt out. In fact, in many cases, even the exploratory data is not complete. The normal plant planning exercise which integrates the working conditions, the phased programme of work according to a prescribed time schedule, the quantities of different items of materials available from given sources, and various other job conditions, is generally not done at that stage. What is actually done is to decide upon purchase of certain items of equipment in different categories, considering these to be general nature requirements for the job. Bulk purchases of equipment are made subsequently, when it is difficult to consider the standardisation—aspect properly.

1.5.2.4 *Inadequate records and collection of data on performance*

Most often sub-standard equipment have been purchased due to lack of adequate information on performance of such equipment working with other users. The performance of such sub-standard equipment being very unsatisfactory, collection of other equipment to complete the job during the peak period is resorted to. Such collection contributes to the assortment of equipment with the user.

Very little effort, if any, is generally made in the direction of collection of information with regard to performance of various makes and types of equipment from those users of equipment who had have considerable experience with such equipment over periods extending 6 to 8 years, or even more. Procedure to be laid down for collection of performance data from such users has been discussed in detail in Chapter 6—"Interdepartmental Coordination in matters relating to Construction Plant & Equipment."

1.5.2.5 *Changes in models due to fast development*

Another important factor, generally contributing towards collections of large number of makes of equipment in the country, is the rapidly changing models of equipment in foreign countries, with total discontinuance of some of the models of machines in different makes. Some times, even the manufacuring plants have completely closed down due to the Companies charging hands and getting merged with some other reputed manufacturers making different makes of equipment in the same categories.

There has been tremendous technological advancement in the development of heavy earthmoving machines over the last two decades. The revised versions of particular models of equipment have been introduced from time to time incomporating substantial changes and improvements in the technical design and construction features of the components used on the machines, and consequently the technical characteristics of performance of the machines. Purely commercial necessity to score a point over competitors, sales gamuts, gadgetting often for the sake of it, have also contributed to a certain extent to frequent change of models.

In order to illustrate this point, the Committee have made a case study with regard to such development in the product-line of one make of equipment, viz., "Caterpillar". As a result of this case study, it is observed that in the Caterpillar D8 Tractor, approximately 950 major improvements have been built into the machines since the time of its first introduction in the year 1935. The Horse Power of the Diesel Engine used on the Tractor has been almost doubled over this period—the present Horse Power rating being 270. Furthermore, during 50's Flywheel Horse Power of the Caterpillar D8 Tractor was increased from 148 to 235 and the weight of the machines was increased by 10800 lbs. Subsequently in the Undercarriage components, where lubrication was earlier recommended every 10 hrs., the components were made life-time lubricated.

Following is the table showing models of Caterpillar equipment in different categories as during the 1950's and as during 1960's.

NEW PRODUCTS OF THE 1950's

Wheel Tractor Scrapers :

DW15*
DW20*
DW21*
No. 619*

Track-Type Tractors:

D9

Scrapers:

435	463	491
No. 20*	442*	470*
No. 21*	428*	456*
No. 60		

Loaders:

933 Traxcavator*
955 Traxcavator
977 Traxcavator.

Motor Graders :

No. 14

Pipelayers :

583
572

New engines, bulldozers, rippers and controls.

*Non-current.

NEW PRODUCTS OF THE 1960's

Wheel Tractor Scrapers	*Wheel Dozers*	*Wheel Loaders*
613	824	992
J621	834	988
621	*Compactor*	980
	(Currently)	
627	824(825)	950
	834(835)	944*
631		922*
632*		930
633		920
641		
650		
651		
657		
660		
666		

*Non-Current

Track-Type Tractors	*Trucks*
Dual D9	769
D-5	779*

Pipelayers	*Traxcavators*	*Motor Graders*
594	983	No. 120
561	951	No. 16
571	941	

*Non-current.

A Comparative study of the new equipment as of 60's and as 50's would clearly reveal the change in models. Accordingly, the multiplicity of models in given makes of equipment, as amassed in India, specially when equipment has had to be largely imported in absence of indigenous equipment.

The implications of the change in models as in case of Caterpillar Equipment, when considered in relation to various other makes mentioned against each major category of equipment in paras 1.5.1.1. to para 1.5.1.5, can be readily understood to explain the number of makes and models of such equipment in use in the country. This, however, is an inescapable position and has to be faced by anyone using imported equipment. As long as indigenous manufacture of such equipment does not get developed to the required extent in the country, the position will continue to be a source of anxiety. The partial remedy, that can be introduced, is by way of making preferential choice of equipment limited to known and tried makes and models thereof as have given satisfactory performance, supported by proper service by the dealers/distributors/foreign principals in the matter of technical know-how for repairs and maintenance and the supply of spare parts etc., therefor.

1.5.2.6. *Attitude of the Users*

Inspite of the difficulties faced by the users of equipment in the country with regard to satisfactorily utilisation of equipment due to non-standardisation and assortment of various makes of equipment, the desire to purchase such non-standard equipment is still in existence with several users in the country. In most of the cases, the users in the country do not reconcile themselves to use the indigenously available machines and simultaneously contribute towards the improvement of their quality through constructive suggestions. Instead, they project the conviction that the performance of the indigenous equipment is not of the desired standard. Some of the users, in order to avoid purchase of indigeous equipment, prepare technical specifications of the equipment required for a given job in such a manner that the indigenous equipment may not meet the required specifications and thus not find a place in the competition. In this process, they sometimes prefer to import non-standard equipment which are never tried before in the country. Such attitude on the part of the users has to be eliminated so that best use of the resources available in the country can be made, and assortment of machines can be reduced for overall improvement in utilisation.

1.6 **Indigenous Equipment**

Indigenous manufacture of items of construction plant and equipment started in the early 60's, covering initially only a few makes of machines in some categories and of small and medium sizes. The modest beginning so made produced small quantities annually. Over the last decade, however, not only the quantity in production increased substantially, but the product mix covered by the manufacturing programmes offered additional new items of machines in different categories and in much bigger sizes thereof. With the present emphasis on import substitution, self-sufficiency and self-reliance, a still larger variety of equipment by categories and sizes is programmed to be manufacture in the country. Even though it will take some more time for the total requirements of construction industry and industries in other important sectors like mining etc., to be met with from indigenous sources, it is reasonably hoped that the imports will be reduced to fairly low levels by the end of the 4th Plan period.

Since the indigenous equipment alone will form the backbone of the industries involving large scale use of construction plant and equipment, it is necessary that the programmes of manufacture of such equipment be suitably augmented. Special care would have also to be taken to ensure that the items of equipment selected for manufacture are of standard designs technically. Moreover, the quality of the products should be such as would infuse a feeling of confidence amongst the users in making future replacements of imported equipment already working with them, by indigenous equipment,

1.6.1 *Items of Indigenous Origin*

The major items of construction plant and equipment manufactured in the country are the following:—

(i) Power Shovels and Cranes:—Shovels of $1\frac{1}{2}$ to 3 cu. yds. and 6 cu. yds., capacity; Crawler Cranes upto 80-T capacity; Mobile Cranes upto 15-T capacity; Truck-mounted Cranes upto 24-T capacity.

(ii) Dumpers:—15-T and 35-T Payload capacity. (The manufacture of 25 to 27-T. pay load capacity Dumpers is about to commence from end of 1971).

(iii) Scrapper, Motorised:— 14.7/18 cu. yd. capacity; Scrappers Towed—10 cu. yds. to 18 cu. yds., struck capacity.

(iv) Motor-Graders:— 115 h.p.

(v) Crawler-Tractors:—95 h.p.; 165 h.p. and 250 h.p.

(vi) Front-end-Loaders, Wheeled:— 2 cu. yds capacity.

(vii) Air Compressors:—Various sizes upto 1000 cfm. and even more.

In addition, Crushing Plant, Screening and Processing Plants, Belt Conveyors, Vibratory Rollers, Dredgers, Tugs and Barges etc., etc., are also being manufactured indigenously.

1.6.2 *Population of Indigenous Equipment*

From the information received from various users in respect of details of equipment of indigenous origin in use in the country, it is estimated that over Rs. 70 crores worth of indigenous equipment is already in operation. This would make about 20 to 25% of the total value of the equipment available in the country. The information compiled on the population of indigenous equipment is at Appendix 1.8.

1.6.3 *Major Manufacturers*

The major manufacturers of equipment in the country are listed in Appendix 1.9.

With the exception of Excavators of $1\frac{1}{2}$ cu. yds. to 3 cu. yds. and 6 cu. yds capacity, most of the other indigenous items of equipment are of recent origin. It will take a period of 3 to 4 years for the manufacturers to get fully geared up for production, to satisfactorily meet the requirements of prospective users of such equipment in the country.

1.6.4 *Future Production Programme*

Though there is no clear indication of the future programme of manufacture of these items, the planning in this respect as so far done in terms of the quantity, machinewise, that will be produced by the manufacturers in future, is given in Appendix 1.10. It could be only broadly stated that there is dire need for accelerating the pace of indigenous manufacture of principal items of construction plant and equipment so as to meet satisfactorily the future requirements of most of the indentors.

1.6.5 *Quality of Products*

While on the subject of indigenous equipment, it is considered necessary to mention that the quality of the indigenously manufactured equipment leaves much to be desired from standpoint of operational efficiency of the machines and its technical performance characteristics. Many a user has complained repeatedly about the problems they have faced in gainfully using the equipment on the job. In most cases, the quality of workmanship is not upto the mark with the result that breakdowns occur frequently even when the machines are new, thus resulting in avoidable downtime. Hence, the availability of equipment of indigenous origin is not as much as a user would normally expect. There is no doubt that such problems have to be faced at the initial stages of manufacture of the equipment; however, since most of the items of equipment are being manufactured in collaboration with foreign principals, the quality of the products could be expected to be better than what it is. In the opinion of the Committee there is dire need for better quality control, specially in respect of the components and parts manufactured by the ancilliary industry and feed to the original equipment manufacturer in the country. Drawing out complete and detailed technical specifications in respect of components and parts to be manufactured by the ancillary industry, furnishing them with detailed working drawings and specifications of the materials to be used, laying down work standards for manufacture of those components and parts etc., are the few items of details to be specially cared for. While it is not the intention to reflect that due amount of care is not being exercised in this direction, it is only a bread-based conclusion that can be drawn consistent with the performance reports in respect of indigenously manufactured equipment, as received from various users from time to time and put before the Committee, that quality of the end product could be better.

1.6.6. *Coordination between Equipment Manufacturers and Component Manufacturers*

During their visits to various construction and minin projects, the Committee were informed about the breakdowns on diesel engines and premature failure of tyres on different machines of indigenous origin. A complaint was generally made that such breakdowns and failures of assemblies/components etc., occurred within the first 100 to 500 hrs. of the operation of the machines; and the service organisation of the equipment manufacturers inspite of taking note thereof were unable to to arrange for replacement/repairs of the same expeditiously.

In so far as the diesel engines are concerned, the diesel engine manufacturers and the original equipment manufacturers have necessarily a joint responsibility to coordinate with each other for improvement in performance of the engines based on feed-back of information on defects noticed in the field. The inordinate delay in repairs to the diesel engines by the engine manufacturers' service staff results in avoidable down-time of equipment. The manufacturers of equipment have to take the responsibility of arranging for replacement of the engine in the event of a major breakdown within the warranty period or to cause the repairs to be carried out expeditiously.

In respect of tyres, the equipment manufacturers have to make a technical assessment of the design and construction of the 'Suspension System' on their machine. Subject to that being in proper order technically, they have to move the tyre manufacturer to carry out a research if the premature failure of tyres is due to quality of rubber, type of construction of the tyre etc.

In any case, the equipment owner looks forward to the equipment supplier for assistance in expeditious recommissioning of the machine on which such unwarranted and premature breakdowns occur soon after first commissioning of the machines.

A feeling was expressed by some that the original equipment manufacturers were not feeling seized of such problems. However, on further probe in this direction, it was verified that they have moved the manufacturers of diesel engines and tyres to take corrective actions after proper investigation and research. Unfortunately, this was not within the knowledge of the users.

To avoid long periods of down-time of machines and to improve upon the quality of the product for sustained and long term use thereof it will be only proper that while coordination is established between the original equipment manufacturers and the suppliers of components, the customers are also taken into confidence about the remedial action initiated.

1.6.7 *Development of Organisation with Equipment Manufacturers*

The Research and Development Department and the Inspection Wing of the original equipment manufacturer has necessarily, to be properly established and strengthened so that the problems can be suitably sorted out in the areas where they lie and attention is paid to remedy the technical faults in proper time and to cause the improvements/modifications to be introduced in the subsequent production of the machines.

1.6.8 *Selective Choice of Equipment for Manufacture*

Another important aspect to be considered in relation to indigenous equipment is the selective choice of equipment to be manufactured in the country. While the Committee has its own reservations to make in discussing this matter in relation to the particular makes and models of machines undertaken for manufacture in the country, and they consider it not too prudent to go into this matter in this report, they think it necessary to generally refer to the possible role that the technical organisations can play in collaboration with the DGTD in making proper choice of the items to be manufactured in future.

A judicious selection an item of equipment for indigenous manufacture would involve a clear technical evaluation of the technical design and construction features thereof and a study of the characteristics of performance of the machine under conditions obtaining under different job applications in the country. The DGTD may take assistance from an organisation/body comprised of representatives of major users of equipment in the country in this respect. Pooling of experience of the major users of such machines would help make a proper technical assessment and evaluation.

The members of that organisation would also be generally acquainted with the trend in developments of similar equipment in foreign countries. They would also be individually aware of the possible improvements in design and construction features of similar equipment which would entail economy to the end cost of the product produced by the machines. Their assessment and evaluation of the size, productivity, cost of production, maintenance and repair costs would be highly meaningful in making a comparative study of the alternative items/makes of machines from which selection is to be made.

1.6.9 *Equipment Planning Committee*

It is suggested that an Equipment Planning Committee be constituted by the Government of India, which may coordinate with the DGTD in such selection of items of equipment to be manufactured, keeping in view clearly the past experience in performance of certain makes and models of machines of imported origin. For this purpose, such an equipment Planning Committee would equip itself with complete data regarding performance of various models and makes of machines under different conditions of work and use of proper evaluation of the particular products proposed to be manufactured. If any item of equipment is to be completely developed indigenously, the technical details can be certainly sorted out in an appropriate manner by the Research and Development Section of an industry.

1.6.10 *Need for Competition*

Another important consideration that arises in relation to manufacture of indigenous equipment is the "Need for competition." While there is no doubt that there should be greater scope for development of costly equipment in the public sector, but considering the quality of the products and the competition in price of the product, it is necessary that there should be more than one manufacturer for atleast such items, where the potential of requirement is substantial. Crawler tractors, dumpers and the diesel engines used to power the earthmoving machines are the items of importance in this connection. This would also principally take care of the export possibilities in a better manner with due regard to the competition in prices at international level, besides the quality of the products. The Industrial Development policy may have to be suitably reframed to accommodate such thinking.

1.7 **Physical Life of Equipment in Use**

While this subject will be treated in details later, a few observations are made in the context of the appraisal of equipment. In the 'Returns furnished by various users of equipment in the country, certain items of machines, have shown to be available and still working. even though these were purchased in the years 1913, 1924, 1933-37, 1940, 1945-1950. Of course, the oldest piece of equipment finding its origin in the year 1913, is a Steam-driven equipment, a crane. Similarly, machines in 20's and 30's are also mostly steam-driven equipment. No wonder, these are still in use.

Even if we have to consider the equipment purchased in the 50's which is still in use, it can be only indicated that the aspect of 'Equipment Economics' has not been largely taken into account, in continuing the use thereof in certain applications.

Normally, due to obsolescene, an average piece of equipment ages out to the point of its being discarded or replaced in a period of 8 to 10 years. For the bigger size Excavators, Dredgers, Bucketwheel Excavators and Granes, of course, the life may extend from 20 to 25 years, and therefore, it may not be surprising to see such equipment still in use. But to talk of the heavy earthmoving machines and to consider that the items purchased in 50's are still in use when we are already in 70's, it can be only surmised that either the equipment was not fully utilised while it was available, or somehow, it has not been discarded and has been put to use on lighter duty work after its economic life was already over. But the question arises : "Do we consider the aspect of equipment economics in planning our jobs where such equipment is to be intensively used?." So long as most of the equipment is of imported origin and our foreign exchange resources are rather scanty, as they have been in the past, there is hardly any choice that can be made by the equipment owners in following the normal drill regarding replacement of equipment. It is only with ready resources of availability of equipment that one can think of a phased programme of replacement of equipment. Consequently, many have contended with the position, that as long as the equipment can be put to work even for a short time in a year, keep it going and physically live with it, even if it is very old.

The subject of equipment economics also brings within its fold the weighty consideration of the replacement cost of the equipment. While the old items of equipment were purchased fairly cheap, the present revised models and versions of some of those old machines cost 3 to 4 times as much by value. The equipment owners, therefore, feel that in terms of the present day cost of the running and maintenance of the new equipment, it may be more profitable to keep using the old machines. This observation has atleast been made by one of the leading users of crawler tractors using them in single shift operation on land reclamation work. In fact, the satistical information furnished to the Committee, amply proves this stand. In that case, the cost of repair and maintenance of the machines over a period of 12 to 15 years has been fairly low, compared to the age of the machines in number of years of their use in the country on that job.

The physical life of mahines is also expressed number of operational hours and the scheduled life as fixed according to normal standards. For the average piece of earthmoving machine—specially those in the categories of Tractors, Dumpers, Motorised Scrapers, Loaders, Graders, this is generally assumed at 10000 hrs. under normal conditions. In excellent conditions the life is fixed at 12000 to 14000 hrs. From the data received by the Committee from the users of equipment, it is seen that some machines in these categories have worked for 20000 hrs. to 30000 hrs., and these are still in use. It has, however, not been possible for the Committee to get the corresponding figures of maintenance and repair costs of these machines during their life time of use with those equipment owners. Hence, it is difficult to make a clear statement with regard to the economics of maintenance and service of these machines at this stage in their lives.

This again proves the point that we are largely following a policy of: "Live with the machines as long as you can" or "Let it spend its physical life on the job in the country, before it is discarded as scrap or junk."

1.8. **Performance and Health of Equipment**

The large capital invested in the construction equipment and the continuing addition of capital has often raised the pertinent question regarding the productivity thereof. The Government has been correctly concerned with it and this subject forms a very important reference to the Committee. A general appraisal of this aspect has been made in the following paragraphs.

1.8.1 *Information as Rendered by the users*

The Committee, while requesting the users to give information regarding equipment available and value thereof, also requested for information on the present condition whether serviceable, 'under reparis', 'beyond economical repair condition', or 'surplus'. Based on the information received a statement is given in Appendix 1.12.

1.8.2 *Scope of Examination*

The items of earthmoving machines—Power Shovel and Granes, Crawler and Wheeled Tractors, Dumpers, Motorised and Towed scrapers, Motor Graders, Grawler mounted and Wheeled Front-end-Loaders account for over 85% of the total value of the equipment reported to be available. The Committee have, therefore, examined in greater detail the level of utilisation of machines, requirement of spare parts for machines and other aspects with respect to these major categories of items only.

1.8.3. *Availability of Equipment*

It may be seen from the details given in Appendix 1.12, that 66% (by numbers) of the available equipment is in working condition, while by value over 75% of the equipment is in "working condition". The figure of 66% would not indicate the actual availability since some of these machine would remain under repair, or periodic overhaul during the operating period. If this factor is taken into consideration, the actual availability of machines would probably be stated as 53% (.66 × .8) nearly. The machines "Under Reparis" as at the time of reporting the information to the Committee, make 25% of the available machines by number and 20% by value. Machines in "Beyond Economical Repair Condition" account for 9% by number and 5% by value of the total figures.

The Committee would have much rather liked to have the availability figures on annual basis in relation to the items of equipment reported to be available. However, the maintenance of records by the users of equipment would not have made it possible for such information to be clearly indicated quickly. All that could be collected by way of information relating to level of utilisation of equipment, was the figures of working hours of equipment over a period of 5 years and that too from about 1/3rd of the users of equipment.

1.8.4 *Utilisation of Equipment*

It may be stated here that the percentage figures given above in relation to total number of machines and total value thereof, does not reflect the status of utilisation of equipment. Equipment in working condition does not necessarily mean that it is being utilised productively on the job where it is available. The actual level of utilisation is discussed in details in Chapter 2 of the Report.

These figures represent the availability of the machines for useful work. Of course, the availability factor of 0.53 or 53% is rather low. The actual utilisation of the equipment would be still lower due to various jobs/management factors. This certainly is not our aim in actual work. We can contend with a minimum of 66% utilisation, though it should normally be expected to be above 70%. For this to be accomplished, the availability of equipment has necessarily to be aimed at a minimum of 80 to 85% (Specially when it is conventional to provide for 20% standby equipment). For new machines, the availability factor is taken to be 0.9 to 0.95 (or 90% to 95%).

1.8.5 *Factors Contributing to low Utilisation*

The following are the main factors contributing towards the low utilisation of equipment:—

1. Improper plant planning.
2. Lack of proper forward planning of work for sustained use of equipment.
3. Delay in rehabilitation of surplus equipment.
4. Inadequacy of maintenance management Organisation and service facilities.
5. Lack of skilled staff for operation and repairs and lack of training facilities.
6. Lack of proper workshop facilities.
7. Lack of proper planning of spare parts provisioning.
8. Improper working condition.
9. Lack of incentive for labour.
10. Improper management of operation.

The above points have been discussed in details in the Chapter 2, Reasons for Low Utilisation of Equipment.

1.8.6 *Surplus Equipment*

Information had also been called for from the users of equipment regarding equipment that is 'surplus' to their requirements. Most of the users have indicated the category of equipment "beyond economical repairs" as surplus and only a few cases are such where serviceable equipment waiting idle for want of work, with no possibility of its further use with the owner, has been declared surplus. In proportion to the total value of equipment available, the figures for 'surplus' equipment are 12.5% by number and 6.6% by value.

1.9 **Observations of the Committee**

The main object of the exercise regarding appraisal of the construction plant and equipment in the country is to comprehend clearly the scope of improvement in management and control of equipment in the country, so that the capital investment made in such equipment is gainfully and effectively used for maximum productivity. The direct benefits resulting from optimum utilisation of equipment, maximum production thereby and at minimum cost, would substantially help the economic growth of the country. The assessment as such would additionally help to consider ways and means for possible changes necessary in remodelling the pattern of management and control of equipment, as well as determining the existing areas of dificiencies in planning the work with equipment. This would include the basic elements of plant planning with due consideration to economical competence of equipment and its productive ability and standardisation.

1.9.1 *Managerial Factors*

The acquisition of equipment for any job and its subsequent utilisation could be properly accomplished only if the owner is conscious of the need for establishment of proper organisation with competent personnel to deliver the goods.

In addition to the observations made, in specific context of the analysis of information received by the Committee, there are some observations to be made with regard to the functional aspects of equipment based on visits made by the Members of the Committee to the sites of work where such equipment was employed in different sectors. These observations would mainly relate to operation, maintenance, management and control, repair facilities, record keeping, cost control and accounting, procurement of spare parts, inventory control of spare parts and planning of work for sustained use of equipment on the job. Each one of these functional aspects of work incidental to the use of equipment makes a separate subject under the defined terms of reference for the Committee; and these are individually dealt with in different Chapters. Hence, it may not be necessary to give any elaborate details on this account at this stage

1.9.2. *Management and Control of Equipment*

It may be stated that with the exception of a few cases, where a fairly scientific approach to the work of proper selection, upkeep and utilisation of equipment had been made, in most of the other cases, the basic fundamentals of the science and art of earthmoving had not been discernibly grasped for effective implementation of the programmes on which the equipment was employed. The main deficiency was noticeable in proper management and control of the equipment—mainly the coordination between the actual user of equipment in the field and those in charge of maintenance and repair of equipment as well as the procurement/purchase organisations. In some cases even the forward planning for work had not been done with a view to sustaining the equipment in use of the Project continuously.

A few cases also came to notice where the equipment had been purchased much in advance of the actual requirements of the work, or where inspite of the clear possibility of the work to be assigned to some contractual agency, who were normally expected to bring in their own equipment on the job, the equipment had been purchased by the project and kept idle for a long time without use.

The main function of the management—controlling the final economy of the work, through timely watching of the elements of cost involved in production or construction, has also not been properly fulfilled. It is a different matter to be able to do a given item of work in a given time; but to do it economically is the main criterian for efficiency and success in completion of the work. Most often, the initial set back has been suffered due to improper selection of the equipment, and to some extent, the assessment of requirement of equipment in relation to phased programme of work, timewise and quantity-wise. The fact that certain big jobs have been completed more or less in a given time, but with equipment utilisation being at an average less than 50%, clearly reflects that too much of equipment was put on the job; or purchased for the work initially. This is a clear evidence of under-rating the productive ability of the machines much out of proportion to the rated capacities and specifications thereof. Obviously, the norms adopted for making assessment of performance of equipment, or for providing spare parts for maintenance and repairs of machines during the life time of a project, have not been proper. In most cases, the low availability and utilisation of equipment has been there inspite of fairly large stocks of spare parts held by the owners of equipment.

The procedural difficulties in procuring spare parts of imported origin have, no doubt, partially accounted for the growing stocks of spare parts and greater down-time of machines; but a scientific approach to the problem could have certainly minimised the resultant cumulative effect manifest in lower availability of the machines.

1.9.3 *Selective Choice of Equipment*

Selective choice of equipment normally involves a degree of specialisation so that an individual segment of a job is handled by the most economical method known. The system of production to be adopted has to receive the prime attention—it has to be reduced to the problem of more perceptively matching the machine to the job conditions. This subject, no doubt, is rather complex (as a part of the plant planning exercise)—one that can greatly effect the economy in end cost on the job, even if it involves close tailoring of a "spread" to the work. Guide lines in this respect, which are considered valuable, and are generally available to the management, have been followed only partially.

The following six points give a broad outline of these guide lines:—

(*i*) What terrain is to be negotiated by the category of equipment? Does it involve any structures enroute which impose limitations on axle weight, or the total weight of the machine?

(ii) What is the haul distance and the type of haul road in terms of rolling resistance figures, gradients, bends etc.?

(iii) What are the operational requirements properties of materials to be handled in terms of weight, swell and compactability, production targets, in terms of units per hour/day/month/season of haulage, dumping, spreading and compaction?

(iv) Is the work to be done at high altitudes or under normal conditions of Mean Sea Level?

(v) Is it necessary to have only Diesel Operated equipment, or that electric power is also conveniently available? In the latter case, if the power transmission lines have to be specially extended to the work area, what expenditure is involved in doing so?

(vi) What is the scheduled programme of work, progress, estimated cost per unit etc., if any such data is available on pre-reckoning basis—as per budget control estimate etc.?

1.9.4 *Qualified Personnel*

Unfortunately, the expense bill on account of pay of qualified and trained hands is always attempted to be reduced by recruiting low paid staff who have relatively lesser experience and skill in the trade on which they are engaged, in any outfit using large fleets of equipment. It is time that we set our minds into a new frame in so far as the work with costly equipment is concerned. It is not to be implied that higher pay to the people would be enough of an incentive to get better results; but what is more necessary is better pay for better qualified personnel engaged on supervising the equipment operations, for operating the equipment, or maintaining or repairing it. Extra expenditure on training of the Supervisors, the Operators and Mechanics would pay very large dividends through extra production and lesser down-time with given fleet of machines. After all, each Operators' and Mechanics' wages amount at an average Rs. 5000/- per year, while the equipment which they are entrusted with for operation and repairs costs at an average Rs. 3 lakhs (though individually, the cost of the machines may range anywhere from Rs. 1.5 lakhs to Rs. 25 lakhs for an average spread of machines)

1.9.5 *Training*

The question that arises is, "How far did we augment the training programmes and facilities for training of skilled Operators and Mechanics to man these machines for efficient operation and optimum utilisation?". There is hardly much substantiating evidence in this direction. Most often, the Operators and Mechanics have been trained on the job. The cost of such training in terms of useful production hours lost while the machines were engaged on training of the personnel cannot be conveniently evaluated; but a general statement can be conveniently made, based on the figures of utilisation of equipment, as shown in the returns received by the Committee. These figures clearly show that the average utilisation of the equipment was about 50% or below

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of the annual scheduled time. This is too heavy a price to be paid for training of personnel if this is evaluated in terms of loss in production. Of course, it cannot be stated that the low utilisation was entirely attributable to the time lost in training of personnel; but certainly, a large portion of the loss in available time could be apportioned to the inefficient operation of the equipment or the down time of equipment at the hands of inexperienced Mechanics, while the machines were under repairs.

The precise implications of the inadequacy of training arrangements and the need for remodelling the pattern of training, are discussed in a later Chapter, corresponding to term of reference No. viii.

1.9.6 *Record Keeping*

Growth of cost consciousness all along the line of control could be better if proper record keeping is done by the owners of equipment. It is not a mere fact of recording the number of hours worked by the machines each day, week, month, a year, or cumulatively during the life of the machines on a job. It is more of the data on technical performance of the machines which enables the owner of equipment or the Manager, to clearly identify the areas in which more attention is to be paid—whether by reorganising the whole operation with equipment, reallocating the equipment for different jobs for better production, rearranging the system of coordination in different sections of the organisation for better control of equipment mainly with a view to reducing the down time of machines, the need for determining the periodicity and frequency of inspections for preventive maintenance etc; and therefore, these records should be properly maintained. Such record keeping is of utmost importance and must be so organised that the senior officers supervising and managing the operations become important partners in the whole operation. The clerical work of filling in pro-formae of information, or transposing such information from one form to another for consolidation of accounts, is more of an accounting matter. The significance and importance of each item of information so compiled is of greater consequence. Continuous examination and study of such information and prescribing necessary changes in methods of work for improving the efficiency of operations, also results in effective control of economy of operations.

The management aspect covers an extensive field and this makes a specific term of reference for the Committee. All suggestions in this regard defining the scope of improvement in the existing methods and system will be made in that Chapter.

1.9.7 *Sharing of Experience*

Another point to be mentioned is that relating to the exchange of information amongst users of equipment. Besides the consolidation of information regarding performance of equipment in the completion reports on completion of certain works, or publication of the information at periodic intervals during the course of execution of an item of work with equipment it is necessary to have a means to arrange for direct dialogue amongst users of equipment in the matter of technical problems faced by them in using individual items of equipment, or in relation to application of certain items of equipment in given systems of work. Compilation of publications is a time-consuming process and at the readers' end certain points that he has to make in specific context of the job conditions obtaining on his work, where similar equipment is in use, would have to be referred to the authority issuing the publication. But it would take very long for any final and agreed views being developed on a subject for expeditious change in the methods to be adopted for better success in the use of equipment. Engineers' Seminars provide the best forum for such dialogues and exchange of views face to face, amongst the users of equipment. Such a system is conspicuously lacking at the present time. It will be very helpful to the main cause of better utilisation of equipment, if periodical exchange of views of the users of equipment is arranged through annual Seminars or subjects of common interest to them.

1.10 **Summary of Observations**

Though varying figures of estimates regarding population and value of construction plant and equipment available in the country have been quoted in the past by certain equipment dealers associations, the assessment by the Committee based on information received from users places the figures of population at 20,000 Nos. and the value at Rs. 3,500 million as on November, 1970. 80% of this value figures viz., Rs. 2,800 million represents the cost of major items in 5 categories—power shovels and cranes, dumpers, tractors (wheeled & crawler) with attachments, motorised scrapers and graders.

For future reference, for assessment of requirement of spare parts etc., this may be taken as a base.

Analysis of the information received highlights the following: —

(i) Value of indigenous equipment available in the country with various users is Rs. 837 million.

(ii) Value of equipment added in 5 years period: —

1961-65 . . .	Rs. 1,000 million,
1966-67 . . .	Rs. 1,300 million.

(iii) Equipment purchases touched the highest figure of Rs. 380 million in an year during 1965 while in 1969 the figure of purchases was Rs. 330 million.

(iv) The Sector-wise distribution of equipment is as follows: —

I & P Sector . . .	Rs. 1,392	million
Public Sector Undertakings .	Rs. 879	million
Other State and Central Government Departments .	Rs. 384	million
Private bodies . .	Rs. 265	million

There is huge assortment of makes and models of machines in individual categories even at single locations. This is a direct result of the scarcity of free foreign exchange, availability of foreign exchange funds from different sources at different times, delay in development of indigenous manufacture of equipment, the prevalent practice of purchases against open tenders at lowest cost in absence of precise information regarding performance—satisfactory or otherwise of equipment of various makes and of different countries' origin.

Resultant lack of standardisation, which is manifest in the huge assortment of equipment, has resulted in low utilisation of equipment, increased inventories of spare parts for maintenance and repairs, equipment being rendered inoperative much before the end of schedule life, rendering surplus some equipment without finding a prospective user for subsequent use and above all, comparatively higher cost of production of the end-product of these machines.

The level of production of indigenous equipment is fairly low, which necessitates import of equipment for jobs which cannot wait. If emphasis is to be laid on import substitution, not only the licensed programmes of manufacture of equipment should be augmented, but the scope of indigenous manufacture should be enhanced to cover additional items for manufacture.

The quality of the indigenous product is a matter of concern to the users. More rigorous and effective controls are called for in this direction so that the equipment can be put to optimum utilisation and the desired economy in construction/production costs can be achieved. For international marketing purposes also improvement in quality of indigenous product is essentially called for.

High price of the indigenous equipment is a disturbing factor for the purchasers of equipment. For those who are engaged on production of commodities (mainly in the mining sector), which have to be sold in the international market, this is of greater consequence.

Record keeping in relation to performance of equipment, operational data costs and statistics, is inadequate. This is one of the reasons why, in spite of the utilisation of equipment being much below the standard levels, an average user is not conscious of the same. The main emphasis is often on getting the job done rather than doing it economically also.

The work on projects involving intensive mechanisation is often started without prior meticulous plant planning. Consequently, considerations of economy in production costs are not realised.

Sometimes the project reports do not even include precise information regarding type and nature of material to be handled by equipment, the quantities that would be available from

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particular locations etc., etc. Overall assessment of requirement of equipment remains a continuous exercise, throughout the life of the project/work. Thus the standardisation of equipment becomes a difficult task in relation to a given work. It also becomes a difficult task in relation to a given work. It also upsets the basic plan of repair and maintenance facilities causing undue increase in investment on this account.

Occasionally the phasing of procurement of equipment is not properly done and fairly large number of machines are purchased much ahead of the actual time of their requirement on the job. This makes the capital investment unproductive and also causes unnecessary avoidable expenditure in maintenance, storage etc., of the machines, besides their getting physically deteriorated.

Equipment ages out faster due to employment of operators and mechanics not having the required degree of skills in their trades. Training of such personnel on the job is the prevalent practice.

An average user of equipment in the country is not fully conscious or mindful of the overall economy in equipment operations. This is partly due to the prevalent system of accounting and partly in consequence of the pattern of the organisation managing equipment operations. Coordination of activities being performed by the Operating Division, the Servicing and Maintenance Division, and the Maintenance Materials Management Division, is not effective to the required extent. Perhaps, a scientific understanding of the subject of Equipment Economics from the point of time when equipment is selected and fitted into a particular plant lay out and design exercise to the time of discarding equipment when it is no longer economical to run, is called for.

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CHAPTER 2

ASSESSMENT REGARDING LEVEL OF UTILISATION OF AVAILABLE EQUIPMENT

2.1 Need for Equipment Scheduling for Assessment of Utilisation

The assessment of level of utilisation of available equipment involves the exercise of equipment scheduling so that certain standards can be predefined for comparative study and assessment. Basically, equipment scheduling is related to utilisation and availability of the equipment selected for the given job.

2.1.1 *Ideal Schedule*

An ideal programme involving large scale mechanisation of works would include every item of equipment working all the time. With the complexity of the present day machines and as a result of technological advancement in the design and construction features of the modern equipment, the trend to larger and faster and as a result more costly equipment, requires that the equipment owner should reckon with every possibility to keep the equipment operating around the clock, 7-days per week.

2.1.2 *Physical and Mechanical Conditions*

In practice, the physical limitations cannot obviously make this ideal schedule possible. Principally, the mechanical conditions, besides the operating conditions and 'human nature' seldom result in such ideal situation to be created. This may, again not be profitable or feasible economically, because of the premium pay for holidays and Sundays, limitations imposed by the provisions of the Workmen's Act or Legislation, which lays down penalties for week-end work, or work on holidays etc. All the same, the cost conscious owner of equipment would normally be expected to strive his utmost to keep as many pieces of his equipment working efficiently as much of the 'work day', as possible, so that the optimum utilisation of equipment can yield maximum production at minimum cost.

2.1.3 *Climatic Condition*

The climatic conditions also cause certain limitations to the period of time for which the machines could be continuously used in a year. On River Valley Projects, the flood season and the rainy season, account for almost 3 to 4 month's shut-down of operations with equipment while in certain places, where snow-fall and severe winter conditions prevail, the period of shut-down of equipment may be of the order of 5 to 6 months in a year.

2.1.4 *Evaluation of Factors for Economic and Product*

Obviously, therefore, in relation to the subject of equipment utilisation, several factors which directly or indirectly tend to influence or increase the cost of the end production have to be evaluated. The plant planning exercise covers this consideration, since operating efficiency requires the minimum equipment to move the predetermined quantities of materials in the prescribed period of time. This exercise takes into account conventionally production schedule in terms of cubic yards or tons of material per hour, per month or per year. But eventually, this has to be translated into a unit measure of the material moved, or handled per machine, per unit of time, in order that judicious selection of equipment—by way of types, categories and numbers can be made with due regard to economy in overall operation.

Too much of equipment may unnecessarily increase initial investment and reflect comparatively lower utilisation of the available machines, while lesser number of machines may make it difficult to fulfil the requirements of the work schedule and over-strain the machines with resultant break-downs in the long run and correspondly, low utilisation.

2.2 Availability factor for Equipment Scheduling

2.2.1 *Equipment Availability*

Availability of equipment is also an important factor in equipment scheduling. In brief, this is a measure of the total time for which the equipment selected for a given job would be available for actual production during a predefined period of work. This could be expressed as an average figure in number of hours per shift, per day, per month, or for the whole season. It is conventional to reckon with the figure of availability in relation to the total scheduled working time in number of hours per year, or per season of work. For example, when scheduling a Shovel, if 80% availability is a common factor, it would mean that of every 100 shifts, 80 will be productive and 20 will be lost for repair.

2.2.2 *Availability Factors*

Availability of equipment is further classified under two heads—'mechanical availability' and 'physical availability.'

2.2.2.1 *Mechanical availability*

Mechanical availability is defined as the equipment availability, except for time lost purely for mechanical reasons. This is expressed as a factor of the operating hours of the machine to the hours the machine would have worked had it not been under repairs or

$$=\frac{\text{Operating hours}}{\text{Operating hours}+\text{repair hours.}}$$

2.2.2.2 *Physical availability*

Physical availability is the total operational availability and considers time lost for any reason. This is expressed as a factor of the operating hours plus the stand-by hours to the total hours available for the work, or

$$=\frac{\text{hours worked}+\text{stand-by hours}}{\text{total available hours.}}$$

The stand-by hours as indicated, is the time a piece of equipment is mechanically available for operation but not used due to occasions arising from operational or economic reasons. For example, in case of a mining or tunnelling operation, where several operation cycles are to be carried out for getting the end product in the scheduled time—drilling, blasting and then loading and hauling etc., a part of the equipment has to remain idle during some of the operation cycles even though the equipment is otherwise mechanically available to do the work. These idle hours are termed as 'stand-by hours' and are taken into consideration to express the physical availability factor.

This can be better understood by quoting the explanation given in the publication "Surface Mining" published by the American Institute of Mining, Metallurgical and Petroleum Engineering, New York:

> "Physical availability is basically a historical record of a machine, showing what use was made of previous time. Although a machine may be mechanically ready for service, occasions arise when, for operational reasons, it may not be appropriate or economic to use it. Physical availability accounts for this condition. This is a useful item in a general appraisal of the mechanical performance of equipment and may also be used as an indicator of the efficiency of a machine scheduling programme.
>
> If the physical availability is considerably higher than the true mechanical availability, the equipment is not being used to capacity, and a thorough study of the operations would be desirable. Such a study could show whether a machine was deliberately light-scheduled (isolated area, smaller machine, or performance etc.) or if poor planning underworked some of the equipment at the expense of the equipment balance."

To illustrate these availability factors further, the following example is given:—

Total hours available during a period in 2-shifts operation .	3000 hours.
Working hrs. during the period .	1500 hrs.
Repair hours during the period .	500 hrs.
Stand-by hours during the period .	1000 hrs.

$$\text{Machanical availability} = \frac{1500}{1500+500}=0.75$$

$$\text{Physical availability} = \frac{1500+1000}{3000}=0.83$$

$$\text{Effective utilisation} = \frac{1500}{3000}=0.50$$

Physical availability is generally higher than the mechanical availability. The two can become equal when the stand-by hours become zero. The level of operation will tend to increase if the physical availability approaches the mechanical availability.

2.2.2.3 *Index of utilisation*

This indicates how efficiently the equipment is operating. The effective utilisation is expressed as the hours worked over the total hours available for operation.

For the purpose of reckoning of the availability factor in this Chapter, the availability wherever expressed, has been taken as the mechanical availability only.

2.2.3 *Availability Related to the Intensity of Use*

The availability of equipment has to be further related to the intensity of the use of the equipment every "Work Day". If single-shift operation is involved, there would be ample time during the remaining 16 hours of the day to carry out Preventive Maintenance, or repairs to the machine, thus reducing the down-time of equipment in the working-shift and correspondingly increasing the availability of equipment. The availability in such cases, may be as high as 90%. For 2 shifts operation, every "Work Day", this figure may get reduced to 80%, while for 3 shifts operation per Work Day, it may be reasonable to assume a figure of 70%.

2.2.4 *Availability Related to the Age of Equipment*

With the ageing of the machine in its service life, the availability factor gets substantially reduced. If for new machine, the mechanical availability factor is rated at 90% to 95%, for a machine which has undergone its first overhaul, this availability factor may get reduced to about 80%. With subsequent repairs and major overhauls of the machine, the factor may get further reduced to about 60%, unless, in the meanwhile, in the process of repairing the equipment, new assemblies and components have been used to replace the corresponding items. In the latter case, the availability factor may again get revised upwards though it would seldom be absolutely the same as for a new machine.

2.3 Fixation of Schedule

Integrating the thinking as above for perspective scheduling in fixing up basic schedule of working hours for machines for optimum utilisation on a given spread of construction work, the following points will arise:—

2.3.1 *Daily Schedule*

In making assessment of equipment corresponding to single shift, 2-shifts and 3-shifts work per day, the number of working hours may be scheduled as follows:—

Per day	
Single Shift	7 hours
2-Shifts . . .	12.5 hours
3-Shifts	16.5 hours

2.3.2 *Monthly Schedule*

No. of working days per month:—

25 at an average.

Single Shift	175 hours
2-Shifts	300 hours
3-Shifts	400 hours

2.3.3 *Yearly Schedule*

No. of months per year:—

This would depend mainly on the climatic conditions. Under average conditions obtaining on most of the works where intensive use of equipment is made, it is normally reckoned, at eight months per year, or correspondingly 200 working days. In exceptional cases, these may range from 150 working days per year on the lower side, to 250 working days on the upper side. Further exception to this may be at places where even 300 working days may be available for the work.

Annual working hours which may be taken as a schedule for an average of 200 working days in a year, will be reckoned as follows:—

Single Shift @ 7 hrs. per day –	1400 hours
2-Shifts @ 12.5 hrs. per day –	2500 hours
3-Shifts @ 16.5 hrs. per day –	3300 hours

2.3.4 *Variation in Schedule*

With increased or reduced number of working days, depending upon the climatic conditions and geographical location of the works, or the programme of work as defined by any individual project or department, the reckoning of the figures of annual working hours for schedule purposes would be related to the daily working hours, as given in 2.3.1 above.

2.3.5 *Norms Adopted to Assess the Level of Utilisation*

The above norms of annual schedule of working hours have been used in assessment of the level of utilisation of equipment available in the country and in use with different River Valley Projects, Iron Ore Mines, Coal Mines, Land Reclamation work, Road Building work etc., etc.

2.3.6 *Schedule for Equipment Utilisation*

The following table indicates the scheduled working hours and the average utilisation hours of equipment working in different shifts per year, suitably reducing the available time with multiplying factors. The range of the scheduled hours has also been indicated below the table depending upon the available days (150 days to 250 days per year) corresponding to the climatic conditions.

The figures of annual scheduled working hours shown in the table would be same for every piece of machine in the fleet, inclusive of standby equipment.

Table showing the Annual Schedule for Equipment Utilisation

No. of shifts in operation	Total available time in hrs.	Availability factor	Actual available time in hrs. 2×3	Average No. of days/years on (8months)	Schedule per year in hrs. 4×5	Average utilisation factor	Average utilisation per yr. in hr. 6×7
1	2	3	4	5	6	7	8
One Shift	8	0.9	7.0	200	1400	0.85	1200
Two Shifts	16	0.8	12.5	200	2500	0.80	2000
Three Shifts	24	0.7	16.5	200	3300	0.75	2500

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Range of Scheduled hours, depending on the working days (150 days to 250 days) available in a year

Single Shift . .	1000 to 1700 hrs.
Double Shift . .	1800 to 2800 hrs.
Three Shifts . .	2400 to 3600 hrs.

2.3.7 *Scheduling Stand-by Equipment and Components*

To keep sustained production at the optimum level, stand-by provisions of equipment are made while assessing the requirement of equipment for a given job. These standby equipments are pushed into operation when any equipment on production is withdrawn for repairs or maintenance. Standby provision, therefore, is directly related to the mechanical availability of equipment on a given job. As indicated in the equipment utilisation scheduling table given in para 2.3.6 above, the availability of equipment with different operating conditions have been assessed at 90%, 80%, and 70% for single shift, double shift and three-shifts operation respectively. The stand-by provision for these operating conditions would therefore, usually be assessed at 10%, 20% and 30% respectively.

In practice, it has been seen that excessive standby provision tend to reduce the utilisation of equipment proportionately. Therefore, it is the thinking of the Committee that instead of providing too many standby equipment, stand-by components may be provided for to reduce the down-time through component exchange system. In such cases, whenever any component on a machine needs repairs, the stand-by component is immediately replaced on the machine and the component needing repairs is removed from the machine for repairs. This component that is removed from the machine for repairs, is repaired in Main Workshop at the earliest possible time and kept as a stand-by component for replacement whenever such occasion would further arise. Such a system reduces the down-time on repairs to equipment and therefore, the requirement of stand-by equipment is considerably reduced.

Usually, such stand-by components are required to be purchased along with the initial supply of spare parts ordered along with the equipment. Since the stand-by components are used as spare parts, replacement cost thereof, is met from the repair provision of such equipment and no extra provision is made for purchase of these components.

Since it is difficult to arithmetically assess the exact proportion of stand-by equipment to stand-by components to be provided for at different operating conditions to achieve optimum efficiency with minimum investment, the Committee have generally assessed the figures as per the table given below. For average conditions, these figures may be adopted for assessing the requirement of stand-by equipment and stand-by components for different operating conditions:

Operating Conditions	Standby equipment as a percentage of the actual Nos. of equipment required	Standby components as a percentage of the total cost of equipment
(a) Single Shift . .	10	5
(b) Double Shift . .	15	7
(c) Three Shifts . .	25	10

For crawler equipment the wear and tear on track components being comparatively more, the provision of standby components has to be reckoned at a slightly higher figure. This may be assessed at 7%, 9% and 13% of the cost of equipment for single-shift, double-shift and three-shift operations, respectively. Identification of the items of standby components for crawler tractors has been given at Appendix 2.4, for illustrative study.

2.3.8 *Enhanced Rate of Provision of Standby Equipment for Operations Involving wide Equipment Spread*

To what has been indicated above, there could be an exception of the type as in the case of work on canals and road construction. In such cases, the equipment spread being over very long distances—100 to 150 K.M. of a canal or in case of roads even 200 K.M. and above at a time, better availability of equipment for sustained production work could be assured if the rate of provision of standby equipment could be enhanced. The exact figures of provision would have to be generally related to the actual management and/or the maintenance and repair facilities provided in relation to each job; but at an average, the maximum provision of standby equipment may not surpass the maximum provision of 25% otherwise indicated for 3-shifts work in a concentrated location, even if the work is to be done only in single shift daily.

The management organisation and maintenance aspects have been dealt with more elaborately in relevant Chapters.

2.4 **Economics of Multishift Operation**

In relation to the factor of 'human nature', as mentioned above, the question arises as to whether the work with equipment be done in single-shift, 2-shifts or 3-shifts. Experience proves that the economic gain resulting from intensive use of equipment over 2 shifts and 3-shifts every day, will more than justify minor problems generally encountered in the night-shift work.

2.4.1 *Management Plays Important Role in Multishift Operation*

Multi-shift operation of equipment can result in entailing maximum economy in work, only if the management of operations is highly efficient and best attention is paid to maintenance and repairs to equipment with larger objective of maximum availability and optimum utilisation of the machines. A highly efficient spare parts procurement organisation with proper enforcement of inventory control system, will substantially help in attaining the required degree of success for such economy in multi-shift operations.

2.4.2 *Reduced Investment*

On rough reckoning, it would not be wrong to say that it would require only 1/3rd the equipment to move 'X-tons' material in a 3-shift per-day work, compared to moving the same tonnage operating only one shift per day. In practice, however, the relationship or ratio as above, may slightly vary mainly due to the fact that the efficiency of operation in the night shift work may not be as high as it would be in the day shift. Moreover, the standby provision of equipment for multi-shift work would be comparatively larger so as to ensure adequate availability of equipment.

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During the course of their deliberations with different users of equipment, whose sites of work were visited by the Members of the Committee, the question was generally posed—"Is it economical to run the equipment in single shift or multi-shifts?" Notwithstanding the main influencing factors leading to a straight decision with regard to 2-shifts operation, or 3-shifts operation of machines in preference to single shift operation, mainly the geographical and climatic conditions obtaining at individual sites of work, the main factor to be considered is the investment by way of capital cost of equipment on a given work, and the phased time schedule of execution of the work. If the work is to be completed over a fairly long period, say 8 to 10 years, and the geographical and climatic conditions obtaining at the site of work cause physical handicap for such operations to be carried out beyond a single shift work, it would be obligatory to plan the work with equipment working in single shift. If however, the duration of work is smaller, rigours of climate do not cause a handicap to the working of equipment in 2-shifts or longer every day, it would be only prudent to reduce the capital investment in equipment and plan multi-shifts operation with machines.

2.4.3 *Economy in Overheads*

More intensive use of equipment entails economy in the end cost of production and reduces annual overheads including the element of interest charges, besides the reduction in capital outlay on equipment, for a given job defined in terms of specific quantity of material to be moved over a given period. In relation to the work in semi-Government organisations, or Public Sector Undertakings, besides this consideration of reduced investment and annual overheads, the accelerated rate of depreciation in consequence of multishift work, results in larger amounts of profits due to Income-tax rate structure which provides an incentive to the equipment owner to use the equipment more intensively through multi-shift operations.

2.4.4 *Reducing Residual Life*

Very often, another dominating factor which weighs heavily in deciding the issue regarding 2-shifts or 3-shifts operation is the residual life of the machines, as well as their residual value on completion of the work on which these are employed. It may be a better proposition to organise a 3-shifts operation on certain time-bound programmes of work where the equipment is employed so that the residual value of equipment is the least possible and the amount of charges to be borne by way of idle time depreciation of the equipment after the completion of work (in the event of equipment not rehabilitated elsewhere in proper time), are reduced to the minimum. It is a natural phenomenon noticed by the Committee during their survey that every project authority starting a new scheme for execution, according to a time-bound programme, tries to take new machines rather than the old machines, readily available. It is this feeling of inherent reluctance on part of the project authorities which has also to be given proper consideration in deciding as to whether or not the equipment operation be planned for 2-shifts or 3-shifts operation.

2.4.5 *Determination of Economical Shifts of Operation*

The Committee have further examined this issue by working out some exercises assuming certain quantity of earth work to be done in a defined period, making selection of items of equipment to do the work, in 3 alternatives, viz., single-shift, 2-shifts and 3-shifts daily over the same given period. The annual working hours corresponding to single shift, 2-shifts and 3-shifts operation of machines were assumed at 1200, 2000 and 2500 hrs. per year, respectively, based on the average utilisation figures as defined at para 2.3.6. The net resultant position arising out of this study is as follows:—

2.4.5.1 *Capital investment*

The capital investment in equipment would be 1 : 0.6 : 0.48 for single shift, 2-shifts and 3-shifts operation, respectively.

2.4.5.2 *End cost*

The net total amount of expenditure in terms of ownership and operating costs of equipment for the same quantity of work in a given period of time reduced to present worth at 6% interest, would be of the order of 1 : 0.816: 0.79 respectively. The basis of calculation is given at Appendix 2.3.

2.4.5.3 *Conclusion*

Hence, the unit rate of work, for the total quantity involved over a given period, was the lowest in 3-shifts operation.

2.4.6 *Standard Practice to be Followed*

The Committee considers that there is a dire need for 3-shifts operations for any work with equipment on jobs where large scale mechanisation is involved, and large fleets of equipment are concentrated in a compact area of work, and this practice should be encouraged. However, individual conditions of work, time-bound programme of completion of the work, the availability of personnel and facilities to man the machines etc., have to be properly integrated in making the final decision in a judicious manner regarding the particular mode of arrangement of work whether in 2-shifts or 3-shifts.

2.5 Accomplishment by Way of Actual Utilisation of Equipment by Different Users

2.5.1 *Scope of Examination*

The Committee had called for information from various Central and State Government Departments, the Public Sector Undertakings and private users of equipment and contractors, regarding total number of hours clocked by the machines from the date of purchase of individual items upto November, 1970, and year-wise details of working hours by different items of machines over the period 1965-66 to November, 1970. Detailed information was received from over 150 such users of equipment in different sectors; however, a fairly large number of returns so filed by them do not give adequate information to precisely judge the average level of utilisation of equipment for purposes of comparative study. All the same, some of the major users of such equipment e.g., Irrigation and Power Projects, the National Mineral Development Corporation, National Coal Development Corporation, Hindustan Steel, Rehabilitation Reclamation Organisation, Directorate General Roads—Roads Wing of the Ministry of Transport, and some users in the private sector, have rendered fairly elaborate details of information in this regard.

2.5.2 *Limiting the Study to 40 Major Projects*

Since tabulation of information in respect of such a large number of users of equipment in the Appendices to this report would involve substantial amount of printing and paper, for purposes of rendering a spectrum of analysis of the information, selection has been made of about 40 major users of equipment—taking a few users from each Sector.

2.5.3 *Limiting Further to 5 Major Categories of Equipment*

Further more, the categories of equipment selected for making an assessment of the level of their utilisation in relation to individual projects/Public Sector Undertakings/Sectors, cover only five items, viz., Power shovels, cranes, crawler tractors, dumpers and motorised scrapers. It is in relation to those categories of machines that the information regarding level of utilisation has been given in details while in respect of the remaining items in different categories of equipment, the information has either not been given too elaborately, or not upto the desired extent. Moreover, these five categories of equipment alone make about 80% of the total value of equipment reported to be available with different users in various sectors in the country. The Committee examined in details the information as received from various users regarding utilisation of equipment for purposes of coverage in this report. Information received from 40 major users of equipment in different sectors has been compiled in the table given in Appendix 2.1.

2.5.4 *Summary of the Statement Compiled on Utilisation*

The names of the users of equipment, the number of pieces of equipment in each category, the year of purchase of the equipment, the figure of weighted average annual hours of utilisation over the period from the year of purchase of the machines to November, 1970, the weighted average annual utilisation over the past five years upto November, 1970, the figures of maximum annual utilisation—relating it to the best performance of any one group of equipment in any year out of the period of 5 year, have been indicated in the Statement.

Separate Statements/Tables as per Appendix 2.2 have been prepared for each category of equipment, covering in each Statement all the 40 users.

The following is the summary of information given in the Statement.

Table Showing the abstract of average utilisation. Abstract of utilisation of equipment with 40 major users.

S. No	Category of Equipment	No. of Users	No. of users with whom the weighted average utilisation of equipment was :			
			80% and above	50% to 80%	30% to 50%	Below 30%
1.	Excavators . .	34	2	6	13	13
2.	Cranes . .	21	2	3	2	14
3.	Tractors(Cr.) .	36	4	7	12	13
4.	Dumpers . .	29	2	6	5	16
5.	Scrapers(M) .	14	..	1	6	7

2.6. Observations

With the exception of one Irrigation and Power Project, namely, the Beas Project, where the equipment has been used in 3-shifts work daily, all other users have worked the equipment in 2-shifts every day. The basic schedule of working for 2-shifts operation of equipment being 2500 annually, utilisation figures of 60% and below, would indicate 1500 working hours per year, or lesser. In fact, this amounts to the maximum of the schedule for single shift operation, if 1500 hours have been clocked. Hence, basically, the performance of equipment in a large number of cases, is equivalent to a single shift operation even though 2-shifts operation has been generally made.

The cross-section of similar information in relation to returns received from over 150 users reflects even a more grim picture in as much as the level of utilisation has been 50% and below, in most of the cases.

The principal observation that can, therefore, be made is that the level of utilisation of equipment with an average user in the country has been 'poor'. The cases of exception to this observation in fact only serve to substantiate this observation. Evidently, there is great scope for reformation with regard to the method and system etc., in planning the requirement of equipment, making gainful use thereof on the job through proper maintenance, repair and management of the equipment. While the complete analysis of the reasons for low utilisation of equipment is given in the Chapter relating to term of reference No. 3, viz., "Reasons for low utilisation of equipment", it may suffice to indicate that the resultant position emerging from the sampling and analysis of the information with regard to utilisation of equipment gravitates the importance of detailed study in relation to each factor/cause contributing towards low utilisation of equipment. The importance of each particular cause or problem has to be judged further in relationship to the overall aspect of equipment economics and to the overall productivity of the machines. Even the maximum utilisation of equipment may not yield the highest productivity otherwise desirable from given items of machines. The variety of details of items so involved in such consideration is discussed in individual Chapters relating to maintenance, repair and management of equipment.

2.7 Summary of Observations and Recommendations

The level of utilisation of equipment with an average user in the country has been poor. Analysis of information with respect to 40 major users reveals the following:—

Average utilisation	Users percentage
80% and above	7%
50% to 80%	17%
30% to 50%	29%
Below 30%	47%

In order to set the aim for attaining optimum utilisation of equipment, it is very essential that basic schedules of operation hours are properly framed. The efforts should not be to either so set the aim or the schedule that in spite of evidently low utilisation of equipment the efficiency in utilisation of equipment is reflected high enough. This would amount to an attitude of attaining self-complecency only.

In defining the schedules, the efforts should not be to scale down the figures because of certain persistent occurrences which take away a part of the available working time. Corrective actions should instead be planned for minimising such losses in time due to recurring troubles.

Further more improvements in degree of maintenance and repairs should be caused so as to minimise the effect of age of equipment in setting the schedules. Arbitrarily scaling down of schedule figures at different stages of life of equipment is not a rational process. After all, in the entire process of utilisation of equipment, equipment economics is to be given the prime consideration so that the main objective of least cost of production is achieved with the minimum possible investment in equipment.

Recommendations

(1) Recommended figures of schedules of working hour in a year with 200 available working days are as follows:—

One shift work per day . .	1400 hrs.
Two shifts work per day . .	2500 hrs.
Three shifts work per day . .	3300 hrs.

(2) Recommended standby provision of equipment and components for different operating conditions are as follows:—

Operating Conditions	Standby equipment as a percentage of the actual Nos. of equipment required	Standby components as a percentage of the total cost	
		Other than Crawler Eqpt.	Crawler Equipment
(a) Single Shift . .	10	5	7
(b) Double Shift .	15	7	9
(c) Three Shifts . .	25	10	13

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CHAPTER 3

Reasons for low utilisation of equipment and low efficiency in operation and remedial measures necessary for improving efficiency in the operation of equipment and for optimum utilisation thereof.

3.1 Areas of Analysis

In the preceding Chapter on "Assessment regarding level of utilisation of available equipment", detailed observations have already been made to significantly indicate the status of utilisation of equipment in the country with different users of such equipment. The resultant analysis of factors contributing towards low utilisation of equipment has to be summarised with a view to clearly define the scope of further improvements necessary to achieve the required standard of utilisation of equipment.

Let it be indicated, at the outset, that even the highest degree of equipment utilisation may not always mean the highest productivity. Unless 'Preventive Maintenance' considerations are properly detailed initially and rigidly followed in practice, it could be least expected that a particular machine in use would give its best on the job. The techno-economic aspects of 'Preventive Maintenance' which are important in this context, would include (i) selection of equipment; (ii) care taking of equipment and (iii) proper record keeping. The record keeping aspect is important for defect analysis, cost evaluation and cost effectiveness. While the main subject of 'Preventive Maintenance' is dealt with in Chapter 10, "Maintenance Procedures", it may be emphasised that selection and care taking of equipment are two important aspects which have a direct bearing on efficiency in utilisation of equipment. Their effect on utilisation and productivity of equipment can be evaluated by the record of performance if properly maintained. The analysis of reasons for low utilisation can be made principally from a study of such record only.

3.2 Reasons for Low Utilisation

The broad classifications of the reasons for low utilisation would be as follows:—

(1) Planning deficiencies at commencement:

  (a) Lack of proper plant planning and facilities at the time of framing of project estimate due to nonavailability of precise data resulting in improper choice of equipment by categories, sizes and quantity, and lack of standardisation.

  (b) Starting work with old and sick equipment without proper facilities for maintenance and repairs.

  (c) Continuous additions of old and sick equipment at different stages of construction of project without augmenting work-shop facilities, or adequately providing skilled staff.

(2) Lack of proper forward planning of work for sustained use of equipment.

(3) Delay in rehabilitation of surplus equipment on completion of certain items of work, resulting in equipment lying idle without work.

(4) Inadequacy of maintenance management organisation and service facilities; and lack of consciousness for organised preventive maintenance programme.

(5) Lack of skilled staff for operation and repairs and lack of training facilities for 'in-service-training'.

(6) Handicaps arising in repairs of machines due to lack of workshop facilities:

  (a) Lack of planning in Workshop Layout inadequate floor space, handling facilities and workshop equipment and tools; and

  (b) Unhygienic environmental conditions of work in shops.

(7) Lack of proper planning for spare parts provisioning and inventory control.

(8) Lack of proper working conditions.

(9) Lack of incentive for the labour engaged on operation, maintenance and repair of equipment.

(10) Improper management of operation.

3.3 **Discussion on the Reasons for Low Utilisation and Suggestions for remedial measures.**

The following will provide elaboration of the above points so as to explain clearly their importance and significance in relation to the work on which the machines are employed.

3.3.1 *Lack of Proper Plant Planning at the time of Framing of project estimate due to non-availability of precise data resulting in improper choice of Equipment by Categories, sizes and Quantity and Lack of Standardisation.*

3.3.1.1 *Selection of equipment with scanty details in Project Estimates.*

In most cases, the project estimates give only an estimate of quantities involved in individual items of work. Elaborate details in respect of such items of work are, however, not furnished; and most often, only scanty details are given with regard to the exact type of material to be handled, the precise location of the borrow areas with details of quantity of material to be taken from each, their distance from the actual site of work on the project, the details of the haul reads their length, gradients etc. that would be involved, etc. etc. Certain basic assumptions are made in evaluating each item quantitatively and conditionally. Consistent with these sketchy details, choice is made regarding categories of equipment that would be employed on the job for given items of work, and the numbers thereof that would be required commensurate with the time schedule of operations, or for completion of each item of work. It is more or less an exercise of dovetailing the quantities of works and those of items of equipment into the working schedules as drawn.

3.3.1.2 *Incomplete exploratory work.*

Unless a clear exercise regarding plant planning is carried out, based on precise data regarding conditions of work, type of materials, quantities of material to be handled from each location of materials etc., etc., it amounts only to framing a 'Guesstimate' (estimate based on guess work), regarding equipment to be selected. or the quantity thereof to be provided for purchase. Some times even the exact mode of operations with equipment cannot be precisely decided upon, due to the exploratory work having not been adequately carried out. This makes it difficult for any exercise to be worked out on economy in end cost of work that may be possible with the use of different combinations of equipment by types, categories and number thereof.

3.3.1.3 *Factors influencing equipment selection.*

The general factors which influence selection of construction machinery include:—

(1) The job specification requirements.

(2) Climatic conditions—length of construction season, or operational season.

(3) Topography, which often determines the design grades and the length of haul distance etc.

(4) Availability of equipment from ready sources may be even contractors' equipment.

(5) Characteristics of the soils/materials to be excavated and/or compacted, the main process of handling the materials, aggregate processing, or haulage of excavated material, haulage of concrete from a centralised unit to the placement area etc., etc.

(6) The type of haul-roads available and details of any bridges, super-structures over which the equipment has to move.

In brief, the machine selection for a specific job depends upon three main factors, viz.,

(i) Physical
(ii) Time and
(iii) Cost.

3.3.1.4 *Details to be covered in project estimate.*

To illustrate the points made in para 3.3.1.3 above by an example, it may be mentioned that if on a rockfill Dam, it is intended to provide the required material by excavation from hills in the area, unless the characteristics of the rock

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to be excavated are clearly known, as also the quantity of acceptable rock that would be available from hills at different locations, it would be difficult to decide whether the excavation of rock and its carriage to the rock-fill dam from the borrow areas, should be done with the use of powerful Tractor-Rippers, Dozers, Loaders and Dumpers of certain size and capacity, or by drilling, blasting, dozing and loading with Shovels. The subsequent haulage of the material so excavated, would again depend upon the size of the rock resulting from such process of excavation and also on the haul distance, the type of roads involved its width gradients, curves etc. As an extension to this, it would have also to be determined clearly, if, as a result of study to be made at site, it would be possible to reduce the length of the haul roads by dropping the material through chutes or by dozing it down over the face of the hills to the toe of the hill from where the material would be loaded into Dumpers with suitable loading equipment. Again, if on the top benches the lead involved for carrying blasted rock to the top-most point of the chute is rather small, it may be economical to use Wheeled Loaders to carry the excaved material directly to the feeding point of the chute. In case the lead involved is substantial—generally above 500 to 700 ft., use of Wheeled Loaders may not be economical for haulage and Dumpers of certain size may have to be employed, for carrying the excavated material to the feeding point at the top of the chute.

In this example, the type of material to be excavated, the terrain to be negotiated by the machine and the topography, cover the "Physical" aspect. Selection of the method of work for least time of production cycle and consequently attaining optimum production constitute the element of time. Combination of methods of work by using different tools of production—machines, suitable for the physical condition, resulting in maximum production with least investment or minimum cost of production per unit of material produced, serve as the basic criteria for apt choice or selection of equipment.

3.3.1.5 *Wrong choice of equipment due to inadequate data*

In absence of clear details in respect of items defined in para 3.3.1.3., initial choice of equipment cannot be correctly made. The resultant handicaps that are faced later in actual deployment of equipment on the job sometimes necessitates purchase of additional equipment of a different type and category. The machines initially selected and purchased for the work, then remain unutilised or underutilised.

The Committee have come across a few cases of this nature, on some of the projects visited by them.

3.3.1.6 *Results of improper selection*

Such improper selection of equipment at the outset causes additional investments, delay in progress, higher cost of production, lack of standardisation, larger inventories of spare parts, substantial reorganisation of the supporting maintenance and repair facilities initially planned, besides the extra storage, warehousing, workshop facilities and establishments.

3.3.1.7 *Finalisation of technical details before commencing work*

In order that production/progress schedules do not get upset and the investment costs are sustained at the minimum levels, it is only essential that the "Physical" aspects be very thoroughly finalised after detailed exploratory work before the work on the project commences. Project planning based on this consideration will help in making selective and apt choice of equipment besides ensuring optimum utilisation of equipment and maximum productivity thereby.

The time initially taken to sort out such details may result in slight delay in the commencement of production work on the project; but in the long run, the handicaps to production that may otherwise arise, if the work is started without proper exploration and details of work, could be clearly avoided. Briefly speaking, the approval of a project estimate may tantamount to a clearance/approval in principle in undertaking the work on a given scheme, or project. However, before the work is undertaken, it should be necessary to finalise the technical design estimates and financial estimates based on thorough details of the work to be done. A period of one year may be stipulated as the time between the approval of the project estimates and submission/approval of the design estimate and the financial estimates in relation to different items of work.

3.3.2 *Lack of Standardisation*

If the plant planning exercise is carried out properly before the work commences on a project, it would be possible to determine correctly the items of equipment essentially required and the phased programme of their procurement at different stages of construction or operations on the project. Accordingly, it would also be possible to determine precisely, the extent upto which standardisation of equipment would be possible. The standardisation aspect in relation to given categories of equipment would involve, its make and size, besides the make of the Diesel Engines/Power Units with which the machines could be equipped. These details could then be properly defined so that, in the event of procurement of equipment in stages, a clear policy could be laid down about the makes and sizes of the equipment in different categories thereof and/or the make of the Power Units that would equip the machines. This would facilitate the convenience of enforcing proper maintenance drills, providing proper facilities for repair and maintenance of the machines enforcing inventory control on spare parts and holding down the limits of stocks of spare parts in view of the standardisation in the makes of equipment and Power Units, that would be in use of the project.

It is a general observation of the Committee, that the huge assortment of makes and models of machines in the same category of equipment in use on different projects and the diversity of makes of Diesel Engines and Power Units on different machines at a single project/job, has caused a great deal of inconvenience to the project authorities in maintaining smaller stocks of spare parts, providing adequate facilities for maintenance and repair work and making available properly trained skilled hands for operation, maintenance and repair of equipment. It is these conditions relating mainly to lack of standardisation, which have substantially contributed towards low utilisation of equipment, as also of resultant inefficiency in operation and maintenance of the equipment.

3.3.3 *Lack of Forward Planning of Work for Sustained use of Equipment*

3.3.3.1 *Forward planning before purchase of equipment*

At the inception of the project, the main items of expenditure are construction of buildings and roads, provision of amenities like water, electricity, medical facilities, social welfare items, transport facilities etc. All these are a must for boosting up the morale of the persons to be employed on the job so that the difficult working conditions generally met with on a project do not become a handicap to the employment of persons. It is, however, observed that on some of the projects, fairly large amount of equipment is purchased in bulk even though the same may not be required to that extent at the initial stages. Perhaps, such expenditure on equipment is taken to be the yardstick of progress. This involves serious hazards in so far as storage, warehousing, upkeep and maintenance of equipment is concerned, specially when the adequate storage and workshop facilities may not have been provided at the outset. Moreover, even the trained personnel may not be available for operation and repair of equipment at that stage. Consequently, the machines are underutilised at that stage; and inadequate attention to repair and maintenance during that period causes physical deterioration of machines and their subsequent underutilisation in the following period.

3.3.3.2 *Work awarded to contractors after purchase of equipment*

The Committee have also come across cases where after initial purchase of large number of machines, it was decided to allot the work on the project to contractual agencies private contractors or an organisation like N.P.C.C. Such agencies having their own equipment to do the work, did not take over the equipment purchased by the project for the same work. Accordingly, the equipment purchased by the project remained idle for considerable periods of time.

A view is generally held by the project authorities that in the event of unsatisfactory performance on part of the contractors employed on the job, the departmental equipment could be pushed into operation, so that the schedules of production do not get seriously upset. Such planning certainly results in increased capital investment, which remain unproductive due to equipment lying idle. The interest charges on investment and the idle time depreciation that accrues when the equipment is unproductive and idle, result in substantial losses of revenue and blockade of capital which could be otherwise gainfully used more productively elsewhere.

3.3.3.3 *Lack of understanding on equipment economics*

In some instances, in spite of equipment having been purchased for certain items of work on a project, work was allotted to contractors since the rates quoted by them were cheaper than the estimated rates with departmental machinery. or purposes of bid evaluation, the interest charges on cost of available equipment, idle time depreciation of equipment, cost by way of wages of operational and maintenance staff on the rolls of the project etc., etc., were not taken into account. Once the equipment is purchased, certain items of ownership and operating costs keep accruing to the equipment owners. If these are not accounted for, it is only false economy in getting the work done by an outside agency at allegedly cheaper rates. Moreover, underutilisation of equipment is a direct consequence of such a situation.

It has also been observed that in such cases, some of the contractors quit the work after doing only a small portion—easier portion of the work, allotted to them. The remaining portion of the work which is more difficult in nature, is ultimately to be done departmentally with project's own equipment. This presents a rather disturbing position.

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3.3.3.4 *Phasing of procurement*

Another aspect which causes idle time of equipment is the improper phasing of procurement. There are occasions when, due to availability of funds/foreign exchange, a major portion of the total equipment for work on the project is purchased in a lot, even though only a part of it would be required in the initial stages of work at least for the first two years. In principle, this is a similar case, as referred to in para 3.3.3.1.

3.3.3.5 *Proper scaling of requirement*

In order to meet the contingencies referred to in paragraphs 3.3.3.1. and 3.3.3.4., it is essential that a clear schedule of phased programme of procurement of equipment be initially drawn. This could be done only if the scale of requirement of equipment is clearly laid out commensurate with the work-load requirements relative to the time schedule of operations on the project. Such phasing and scheduling alone will result in economy in investments and optimum utilisation of the equipment on the job.

Generally, the peak requirements of work on a project may be expected in the third or the fourth year of construction. That is the time when the maximum number of machines have to be pushed into operation to sustain the level of production at the optimum. If the bulk of equipment is purchased initially in one lot, it is generally not in proper condition to give the optimum production at the 'peak requirement' period. If, however, the equipment is procured in stages, commensurate with the work-load requirement, the additional items which arrive physically in time for the peak requirements, would ensure the required progress.

In this process, it would also be possible to create adequate facilities for maintenance and repair of equipment.

Discrete and judicious scaling of requirements of equipment for procurement would reduce initial investment, give better utilisation of equipment, permit better efficiency in operation through better availability.

3.3.3.6 *Economy in sustained use of equipment purchased for the work*

To avoid idle time costs, it is necessary to ensure sustained operation of equipment throughout the available working time in a construction season/annual. Sometimes enough work-load is not provided for such continued and sustained use. This results either from excessive equipment on the job or in consequence of design details etc., of the work not being finalised in proper time for the equipment to be deployed. Occasionally, some resources, handicaps also cause delay in execution of the work, consequently rendering the machines idle.

3.3.3.7 *Critical analysis and scientific methods of approach to work*

It is also occasionally happens that integration of the resources to do a given item of work is not properly done at the time of commencement of the work on a project. While the initial expenditure on purchase of equipment is incurred, financial resources' handicaps in subsequent period, or nonavailability of some of the scarce materials, come in the way of equipment being consistently utilised. It is most essential that a very clear view be taken initially of properly coordinating and integrating all resources before deciding to invest large sums of money in the purchase of equipment for a given job. In brief, the 'CPM' (*) Charts and 'PERT' (**) Analysis should be the scientific method of approach for work on projects. The exact significance of this is hardly understandable or at least this is conspicuously absent from the sphere of planning of work on projects. If a critical analysis is clearly made, in form of 'CPM' Charts, it may, perhaps, be possible to economise substantially in initial investments of capital on those projects the capital which otherwise gets blocked up unproductively over long periods, mainly in the cost of equipment.

3.3.3.8 *Cell for 'Time and Methods' studies*

Production by earthmoving machines involves repetitive cycles of operation. For equipment utilisation to yield maximum productivity, it is necessary that each cycle of operation involves least time. For this to be done, continuous studies have to be carried out for determining if any delay factors involved in production cycle time can be removed by changing the methods of operation. Such research and study can be done by a separate Cell carrying out 'Time and Methods' Studies.

3.3.3.9 *Centralised plant planning*

Planning of equipment for all works in Irrigation and Power Sector of Maharashtra State is done on annual basis in a Central Cell. Through such planning, it is possible to make the best use of the available equipment. Such annual planning is undertaken 4 to 6 months in advance of the commencement of the working season of the projects in the State as a whole. Knowing clearly the stage of work on each project, and the programme of work for the following season, it is possible to allocate the available equipment to different jobs on various projects and to determine, as to what additional equipment would be required to meet the targeted production figures on each project. The measures that would be necessary to commission any of the sick machines which may be awaiting repairs are also decided upon. By this method, it is possible to properly line out the programme of repair and overhaul of available equipment, so that it can be commissioned in time for work on those projects. This helps in avoiding additional investment in procurement of new equipment unnecessarily. Accordingly, such centrally coordinated arrangement entails lot of economy in investment of equipment in the State as a whole, and avoids idle time of equipment on individual projects.

The equipment can also be reapportioned from one project to another, consistent with the priority of needs, and also from standpoint of standardisation.

3.3.3.10 *Planning by individual projects*

Occasionally, as a result of annual review of requirements of equipment based on the programme of work in the ensuring working season, need for more equiment is established. The additional requirement of equipment is generally met with in such cases by diverting the equipment available elsewhere (within easy reach). Normally, an equipment owning authority would not spare any item of equipment for transfer outside the work under its purview except when the equipment is absolutely surplus to the needs of his work or it is not in good condition for immediate use. The prospective transferee of equipment being otherwise in dire need of additional equipment, is inclined to accept even such unserviceable equipment in the hope that he will able to recommission the equipment after suitable repairs and use it gainfully on his work. Addition of such equipment in 'not too good a condition' aggrevates the problem of timely repair and overhaul of the equipment already available on the project and most often repair to this additional equipment is also considerably delayed. Eventually, therefore, the additional equipment cannot effectively add to the production to the extent it was required to do. Sometimes this also tends to throw off balance the programme of repair and overhaul of the original fleet of equipment. Such partial utilisation of the additional equipment adds to the low utilisation of the equipment fleet as a whole.

(*) CPM—Critical Path Method.

(**)PERT—Programme Evaluation and Review Technique.

3.3.4 *Delay in rehabilitation of Surplus Equipment on Completion of Certain Items of Work, Resulting in Equipment Lying Idle Without Work*

3.3.4.1 *Surplus equipment from jobs of specialised nature*

Occasionally some items of equipment initially purchased to do certain jobs of specialised nature making tunnels for diversion of river, or for lining of the tunnel etc., etc., are rendered idle and surplus to the requirements of the project, soon after such individual items of work are completed. Normally, such equipment should be offered as surplus to other prospective users of the same elsewhere in the country if no such jobs are concurrently at hand on projects, or works within the State. If this is not done, the level of utilisation of such equipment would figure at the minimum figures, if not zero. It is, therefore, most essential that proper forward planning be done in respect of rehabilitation, or disposal of such items of equipment whcih are not required by the owning projects, or organisation at a particular time.

3.3.4.2 *Equipment surplus when Project work tapers off to close*

Similarly, when a time-bound work on a given project is tapering off to a close, action should be initiated to rehabilitate the equipment that will be rendered idle on completion of the work. If advance planning is done in this regard, the available equipment can get shifted from that particular work to other works and kept in use. However, unfortunately, such forward planning is not done by most of the equipment owners with the result that the equipment lies idle without work for a fairly long time. This partially contributes to the low utilisation of equipment during some periods of useful service life thereof.

No doubt, there is another side of the problem which has also to be taken into account; and that relates to the apathy on part of the project authorities undertaking new projects, to take the old and used equipment for their work. A feeling is always expressed that since the project work would last for six to eight years, the old equipment cannot be accommodated on the job. If proper workshop facilities are established well in time (as is otherwise essential even for new equipment) on the new project, the old equipment can be gainfully used. This would ensure better utilisation of equipment already available.

3.3.4.3 *Need for central co-ordinating agency for disposal*

The equipment owners generally take it on themselves to initiate action for rehabilitation or disposal of equipment; and they can do so only after they are free from the work on which the equipment is otherwise employed, i.e., when the work is almost completed. If the disposal, or rehabilitation of such surplus or idle equipment were to be the responsibility of a Central Co-ordinating Agency in a State, or in an organisation, finalisation of action by that organisation to dispose of or rehabilitate the equipment would generally be so synchronised with the time of surplus rendering of equipment that continuity in the service operation of the machines by timely transfer from one work to another, could be suitably sustained. Such a separate organisation for disposal/rehabilitation of surplus/idle equipment, would of course, have to work in close liaison with the Purchase Cell, or the Planning Cell which are responsible for planning of equipment for various works in hand in a State or in an organisation, as also for the procurement of the required equipment.

In relation to the River Valley Projects, the Central Mechanical Units set up in each State in the Irrigation and Power Sector, would help to accomplish this objective to the greatest advantage.

3.3.5 *Inadequacy of Maintenance Management Organisation and Service Facilities; and Lack of Consciousness for Organised Preventive Maintenance Programme*

The maintenance procedures followed by the users of equipment have been separately dealt with in the Chapter 10 of the Report (Maintenance Procedures). The detailed observations given therein, will not be gone into in this Chapter. However, the maintenance management organisation and service facilities which have a direct impact on the level of utilisation of equipment, may be discussed here.

3.3.5.1 *Functions of maintenance organisation*

The prescribed maintenance of equipment, consistent with the schedules laid down by the suppliers of equipment, or their manufacturers, is a routine job to be carried out by the maintenance team employed for the purpose. However, the maintenance management organisation has a relatively and distinctly different function to perform. It is more a matter of carrying out 'Preventive Maintenance' work in a scientific manner that a proper co-ordinating effort is called for on the part of the maintenance management organisation, if the equipment is to be put to optimum utilisation for maximum production. This, however, is more in relation to the large scale outfits using sizeable large fleets of equipment. It is not enough only to plan out proper selection of equipment and its employment on different items of jobs, in a judicious manner. It is equally important to see that the equipment is maintained in a proper shape for continuous working on the job during the working season. This amounts to integration of the factors of inspection, evaluation, avoiding breakdowns by timely check of wear and tear on components, making adjustments, reducing down-times to the minimum through component exchange system, rebuilding of worn out parts for re-use, etc., etc. Timely availability at site of work, of proper grades of lubricants, replacement items, consumables like Wire-Ropes, Cutting Edges, Filters, etc., also are listed as an important function of such maintenance management organisation, to ensure proper utilisation of equipment.

3.3.5.2 *Proper understanding of preventive maintenance*

As it is, on most of the projects, where large scale use of equipment is involved, it is a practice to attend to breakdown maintenance work only, besides the prescribed maintenance drill in relation to the individual items of equipment. Such a practice results in prolonged down-time of equipment and consequently lower utilisation of equipment on the job. It is, therefore, necessary that the 'Preventive Maintenance' Programme in all its facets should be clearly understood by the maintenance management organisation who must make systems analysis for such work and cause effective implementation of any programmes that they may decide to follow, in proper accomplishment thereof.

3.3.5.3 *Planning of preventive maintenance work*

It is worth while dividing the available equipment into categories like Excavators, Dumpers, Crawler-Tractors—the major items of equipment generally in use, where large scale mechanisation is involved. Depending upon the number of machines in use in each one of these categories on a given job, the responsibility of Preventive Maintenance can be assigned to experienced officers depending upon the size of the fleet of machines in each category. These officers in charge of Preventive Maintenance work can continuously carry out the inspection of the machines on a pre-planned basis, arrange to do top overhauls whenever necessary in mid-working season and to make a clear forecast of the likely requirements of parts necessary for overhauling the machines in off-season period, or even during working season period. If this is not done, the work during the overhauling season—the off-season period, gets to be fairly intensive, resulting in overcrowding of machines in the Workshops and it is difficult to carry out the repairs to equipment in a short period—3 to 4 months time of the off-season period—in a satisfactory manner. In fact, quite a few machines cannot be rendered operative due to nonavailability of required parts in time, as no proper forecast had been made in this respect due to lack of inspection of machines at frequent intervals during the working season. Hence, it is very essential that the maintenance management organisation should be so set up and established, that it can effectively execute the programme of prescribed maintenance and Preventive Maintenance in their true sense, in order that the machines are rendered operative to the maximum extent for maximum productivity during the working season.

3.3.5.4 *Servicing facilities*

The servicing facilities—whether for maintenance or for repairs, again play a very vital role in providing assurance for maximum utilisation of equipment. The facilities to be provided by way of servicing equipment, tools required by the machanics for such maintenance and repairs, the covered accommodation necessary for using the machines for proper repairs or by way of providing required spare parts for repairs to the equipment in time, are the crux of the problem. Unless such facilities are properly provided, the availability of machines to the required extent on the job cannot be properly ensured; and consequently, the utilisation of equipment would always be low. The Committee have observed deficiencies in this respect at many places, though, in certain instances, inspite of more than adequate provision of such service facilities, lack of trained personnel to do the maintenance and repair jobs and adversely affected the availability of the equipment to the required extent as well as its utilisation.

3.3.6 *Lack of Skilled Staff for Operation and Repairs and Lack of Training Facilities for 'In-service-Training'*

3.3.6.1 *Lack of skilled hands*

The equipment in use on construction work on River Valley Projects, for Mining Work, for road building, land reclamation etc., etc., is very costly. Each machine would cost hundreds of thousands of Rupees. The care and custody of the machine—for its operation, maintenance and repairs, is, however, entrusted to persons who are not adequately trained and qualified for the purpose. Psychologically, the mental get up of persons operating the equipment, or repairing it, is not such as would make them feel responsible to the required extent for the safety and upkeep of such costly equipment. The confidence on part of such persons to assume proper responsibility for such costly equipment can, however, be infused into their minds only if they are made to understand technically and operationally, the functions to be performed by the machine. Through the process of synchronisation of the functions of the machine with the functions to be humanly performed by the person, it would be possible to make the person to look after the machine better.

3.3.6.2 *Improper training system*

Most often, certain low ranking persons—generally classified as helpers or oilers, take the opportunity of learning operation or repairs of the equipment, while they serve individually the Operator or the Mechanic responsible for operation and repair of the machines, rather than the employer. These helpers seek 'Favours' from those whose commands they follow, in becoming in turn Operators and Mechanics. Some times, this process reaches a point where the Operators and Mechanics personally feel 'care-free' and willingly assign the work of operation or repairs to such lower staff not understanding clearly the implications by way of physical damage that may occur to the machines, either due to faulty operation or due to improper repairs carried out to the machines. It is most unwise and imprudent action on part of the Operators and Mechanics to train their helpers for operation or repairs of the machines in this manner. To ruin such costly equipment through such handling by inexperienced staff, is in fact, criminal. Human psychology being what it is, such persons who are desirous of learning the Operator's and Mechanic's trade so cheaply, must be given a training separately, either through the Technical Training Centres or through an "in-service-training' programme on the project.

3.3.6.3 *Selection of persons for training*

However, while selecting personnel, it is to be meticulously considered that the calibre of the persons selected for such training programmes is of a proper standard. An illiterate person may occasionally have a keen aptitude for learning a trade of an Operator or a Mechanic and he may soon become a deft hand in either of the two trades; but such exceptions are rare. It is necessary to consider selection of persons for such training from amongst the available staff in full consciousness of their basic qualifications, aptitude and necessary skill. This has been dealt with in details in the Chapter 7 on "Training" (Item viii of the terms of reference for the Committee). Exceptions to the basic educational qualifications of persons selected for training could be made only in such cases, as would involve certain persons, who had been working as Mechanics for a fairly long time, or Operators on smaller equipment for a long time.

3.3.6.4 *Plan for training of personnel to be done simultaneous to the Plan for Procurement of equipment*

While planning the work with equipment on a project, it is most essential to evaluate clearly the availability of skilled staff for operation, repair and maintenance of machines. It would be improper to acquire the whole lot of equipment initially, provide for facilities for repair and maintenance of the machines, and yet not have the required complement of staff necessary for operation maintenance, repair of the equipment. During the time the procurement of equipment is processed, suitably qualified persons should be recruited for training through deputation to known training agencies for proper training as Operators or Mechanics in relation to the particular type or makes and categories of equipment being procured. The lead time for procurement of equipment being generally one year or more, it would be possible to have the required trained hands for operation, maintenance and repairs of equipment conveniently, duly trained through such training agencies. Of course, it would be normally expected that at least a contingent of trained hands—both Operators and Mechanics, would also be available initially in response to advertisements calling for recruitment of such personnel. Hence, advertisements for recruitment and sponsoring of candidates for training should be done simultaneously with the action initiated for procurement of equipment.

3.3.7 *Handicaps arising in repairs of machines due to lack of workshop facilities: (i) lack of planning in Workshop Lay-out—inadequate floor space, handling facilities and workshop equipment and tools: and (ii) unhygenic environmental conditions of work in shops.*

3.3.7.1 *Importance of planning workshop layout*

The lay out of Workshop is an expression of the purpose for which the Workshop is established. Unless the type and amount of work to be done in a Shop are predetermined and defined precisely, it is difficult to envisage and estimate the total requirement of work space, the type of accommodation/sheds etc., the main machine tools and accessories to be installed, the handling facilities and other amenities to be provided for the workmen. Even though the project estimates as initially framed for estimating the cost of work, do give a broad outline of the items of works to be done in project workshops, or workshop attached to a production job, like the Mining operations etc., the lay out of Workshop is not precisely determined to afford the convenience of sequentially phased operations involved with a view to ensuring minimum rehandling of items. The expenditure on "handling" alone, sometimes, amounts to over 40% of the total cost of a work done in the shops. Hence, it is necessary that the aspect of planning a Workshop layout is treated with equal importance in the plant planning exercise. Unless this is done, the work on repairs to equipment may not be done methodically and it may take disproportionately larger time to carry out repairs, thus reducing the availability of equipment for proper utilisation.

Care must also be taken to ensure that intermingling of repair and manufacturing shops is avoided. For instance, a Steel Structure Fabrication Shop, put in between the Repair Sheds, or just close to it, would influence adversely the workmanship by the workers engaged on repair of machinery. The details in this respect have been discussed in Chapter 11 of this Report.

3.3.7.2 *Existing shops*

As at present, on most of the projects, or on various production jobs, like Mining etc., the Workshops do not either provide adequate space for the equipment to be repaired or in some cases, the size of the Shops is too large to make the repair operations economical. It is necessary to reconcile such position with actual job requirements.

In what has been seen by the Committee, during their tours to various work-sites of different users of equipment, it was rather unfortunate to observe that at certain locations, inspite of the available facilities, best use was not made of the same. The main factor contributing towards such a situation resulted partly from incoordinated effort in integrating the functions of different shops and facilities, and partly the improper lay-out of the Shops and the facilities. If Mechanical Availability of the equipment is to be the main index of utilisation, it is most essential that utmost care is exercised in proper layout of workshops, organisation of facilities for handling and repairs and provisions of adequately trained staff etc., for supervision and for actual repair work.

3.3.7.3 *Planning the lay-out*

Basically, the exercise starts with the proper selection of a site for the Shops, taking into account the climatic conditions, rain fall, working area, etc. Size of the fleet of equipment to be repaired is then taken into account with due respect to the categories of equipment and the number of machines in each category to be repaired at any one time. The lay out of each particular shop is to be designed in specific relation to the type/category of machines and their number to be repaired. For example, if a fleet of Crawler Tractors, Dumpers, Scrapers and Excavators, is to be operating at a project, the Repair Shop for Crawler Tractors, Dumpers and Excavators would have different types of floors and handling facilities to be provided in each shed. For Crawler Tractors, the Crawler-tracks would make it necessary for the floor to have proper reinforcement to withstand the impact of the Grouser Bars. For the Repair Shop for the Excavators, a pit with proper drainage system, would be necessary, so that the Excavator could be taken into the pit where the normal ground level would be flush with the foot board of the Excavator for affording the convenience of easy dismantling of the upper frame machinery, and the boom etc. The pit would have to be under a roof with proper lifting tackle etc., suitable for heavy loads.

With regard to Dumpers, special care would have to be taken about the overall length of the Dumpers—specially in case of Bottom Dumpers and the height of the Dumper Body, specially in case of Rear Dumpers.

Hence, the provision of the shops would have to be related to the type and size of the equipment to be repaired.

3.3.7.4 *Specialisation*

For all categories of equipment, certain degree of specialisation is necessary in carrying out repairs to items of components of common nature—common to most of the equipment. The layout of Workshop sections for specialisation in component repairs has been dealt with in detail at Chapter 11. The main idea of specialisation is the accuracy and precision with which components, assemblies and sub-assemblies should be repaired in the least possible time. Besides this, such Sections also afford the convenience of providing built-up or repaired components as standby units for minimum repair time of the machines while in the shops.

The degree of specialisation in the matter as mentioned above, mainly ensures the satisfactory performance of equipment over fairly long periods without any great frequency of intermittent breakdowns when the equipment is working on the job. Hence, the degree of precision in repair work is the key-note to the success to be attained through such specialisation.

Even though most of the users of equipment are currently aware of the importance of specialisation by Sub-Division of work in the manner described above relative to the shops established at each work centre, where large fleets of equipment are in use, it is unfortunate that in practice, the method is not effectively implemented. This results in long durations of repair time in recommissioning the machines sent to the Workshops for repairs.

3.3.7.5 *Need for drawings and specification*

Another factor equally important in this context is the know-how regarding measurements, fits and tolerances to which the work of re-assembly of the machines in the process of overhauling is involved. It is vitally necessary that the staff repairing the assemblies, components, sub-assemblies or the machines, must have the Charts showing 'Rebuild Specifications' relative to individual makes and models of machines. If the workmen have such rebuild specification charts, readily available with them, the degree of accuracy in reassembly of the components and the machines etc., will ensure very satisfactory performance of the repaired machine or components.

3.3.7.6 *Supervision and inspection*

The Supervisor/Foreman should be personally responsible to check up the repair work at each stage consistent with the rebuild specification charts. The initial inspection of components/parts at the time of disassembly of the machine, and comparing the wear and tear of individual parts and components, with the standard dimensions laid down in such charts, provide the means for economy in over-all repair work to machines, or the cost of the parts to be used in the process.

3.3.7.7 *Handling facilities and tools*

Similar is the importance of the handling facilities provided for handling heavy parts in the process of dismantling or reassembling the major assemblies or the machine as a whole. If arrangements are to be rigged up individually for each machine for removal of heavy parts, like Diesel Engines, Transmissions, or the bodies etc., it takes inordinately long time to even dismantle or reassemble the machine, besides the extra time taken for actual repairs in absence of proper handling facilities. Hence, in considering the lay-out of such repair shops, it should be a prerequisite to provide either overhead Cranes, or Pillar Cranes at suitable locations to account for such situations.

Provision of workman-benches with vices, racks for storing of parts etc., etc., are again important provisions in absence whereof much of the available floor-space is not left for convenience of repair work by the workmen.

3.3.7.8 *Cleanliness*

Needless to say that in all such lay-outs the basic element of hygience and cleanliness in work makes the fundamental base. As with the human body, the machines require as much tidiness and cleanliness in the working conditions. Pucca floors and metalled roads around, with proper drainage system, are some of the basic elements to be taken into consideration in the layout of shops. Specific care is to be taken of the fact that in areas where the rains are heavy, and if the repair shops are located at the foot of the hills, or near hillocks, the flow of water from the hillside should not overflow the drains and flood the workshop area or enter inside the sheds. These considerations, though evidently of trivial nature, are highly consequential in influencing the conditions of work inside the workshops specially when most of the repairs for such equipment are carried out in off-season—rainy period.

3.3.8 *Lack of Proper Planning for Spare Parts Provisioning, Inventory Control etc.*

3.3.8.1 *Incoordinated Planning in executing repair work*

It has been the experience of the Committee, during tours to various work-sites, that while the spare parts indents are prepared on forward planning basis, the machines, which are sent to Main Workshops for repairs, await the initial disassembly until after a substantial portion of the spare parts earlier ordered has been received. On opening of the machines, after receipt of parts, it is generally experienced that some items of spare parts have neither been ordered, nor are they available from stock; or through incoming consignments. Hence, in spite of availability of a major portion of the required spare parts (80 to 90%), the machine under repair could not be commissioned for want of about 10% of the required parts, which are then termed "Critical'. If the machine had been disassembled and inspected immediately on its receipt in the Repair Shop, it would have saved the owners of equipment quite some time in indenting for the remaining parts, thereby reducing the overall repair time of the machine by 4 to 6 months, if not longer. It is due to such incoordinated effort in planning and executing of the repair programme that the non-availability of parts comes to be a critical factor in the time taken for repairing the machines.

3.3.8.2 *Planning in indenting & procurement of Spare parts*

Most often, the point is made that it takes too long for the spare parts to be procured: and hence, the consequent delay in commissioning the machines under breakdown which ultimately account for greater span of downtime of the machine, and the low utilisation thereof. This is a matter relating to the "methods. system and procedure of procurement of spare parts and inventory control of spare parts". With discrete planning in indenting and procurement of spare parts, the spare parts can be arranged to be made available in time. All that is required is foresight and far-sight, and good record keeping. An experienced and efficient Foreman or a Supervisor, should be able to determine with precision, the nature of defects that keep arising in given makes and models of machines in use at a particular job over periodic intervals of time, and he should therefore, be able to frame requisitions for spare parts commensurate with his observations based on History Records maintained by him. He can supplement this experience with actual observations and inspection in the course of Preventive Maintenance of machines and ordering of the spare parts accordingly, and or preparing requisitions for additional parts on actuals basis immediately after opening the machines received for repairs.

There is no doubt that many other elements or factors enter into consideration, with regard to delay in procurement of spare parts and the consequent nonavailability of spare parts in time. The scarce position of foreign exchange for import of parts, the Import Trade Control policy, the procedures for processing of import licence applications etc., etc., are also some of the contributing factors in delaying the ultimate supply of spare parts in required time, for repairs to machines. However, such factors being prone to periodical assessment in terms of time lag, that would be involved in physical supply of parts on account of each one of these factors, it should not be difficult for the indenting authority to have a near correct idea of the total lead time involved in physical supply of parts. The oft heard statement: "This machine cannot be put on the job, since it is awaiting spare parts for repairs", can be avoided with proper planning for spare parts in a scientific manner.

3.3.9 *Lack of Proper Working Condition*

3.3.9.1 *Haul roads maintenance*

Even though Haul Road Maintenance is an item of maintenance work of comparatively minor nature, and plays the most significant and vital role either in boosting up production and minimising breakdowns of equipment, or in cutting down terribly on production and putting the machines off the road, very few of the users of equipment pay adequate amount of attention to this. A variety of breakdowns on machines is largely attributable to the poor condition of the haul roads with respect to the surface and the formation thereof, the types of curves involved and the severity of the gradients involved in certain portions thereof. Lack of adequate watering arrangements for maintenance of the haul roads—specially to avoid dusty conditions, is also an equally important factor. Provision of Motor Graders and water-sprinklers is most essential in adequate numbers commensurate with the total length of the haul roads. The type of the Motor Grader to be used proper selection of the size of the Grader, is also important. Needless to say that reduced rolling resistance can result in better speeds and this can be achieved through properly maintained and graded haul roads without too much of the advers gradients. Every one per cent gradient requires extra rimpull of the order of 20 lbs. per ton of the gross vehicle weight to overcome the extra rolling resistance on this account. Similarly, while on good and well maintained haul roads approximately 40 lbs./T of G.V.W. is required to overcome the rolling resistance, the figure may increase to 100 lbs./T on rutted and illformed haul roads. Hence, for avoiding breakdowns and for ensuring better production, maintenance of the haul roads in a proper manner is most essential.

The general feeling prevailing in the minds of the equipment owners is that the heavy construction equipment is rugged enough to withstand the rigours of off-the-highway work. This popular belief is misleading and sooner such owners of equipment are disillusioned in this regard, the better would it be from standpoint of utilisation of equipment.

3.3.9.2 *Haul road planning*

The width of the haul roads, the type of bridges and super-structures involved, also play a vital role in cutting down the cycle time of operational equipment. Narrow roads, or narrow bridges and low super-structures, make it difficult for two-way traffic and the resultant low speeds of equipment cause tremendous handicap to production. Sometimes, such conditions result in accidents, which cause downtime of equipment or total loss of machines. If utilisation is to be interpreted as the index of productivity of the machine, utmost care is necessary in planning the operations through proper formation of the haul roads, bridges and super-structures etc. Of course, where such physical limitations are unavoidable, as in the case of road formation in hilly terrain, the initial selection of equipment has to be made so, that such conditions do not handicap utilisation and production.

3.3.9.3 *Borrow areas and dumping areas*

Similar is the position in respect of the working conditions obtaining in the borrow areas or sites where the material is to be handled. Maintaining the borrow areas for materials and dumping areas in proper condition even with the help of Dozers, where necessary, would pay heavy dividends in cutting down the cycle time of equipment hauling the material. It may not be necessary to engage such maintenance equipment on whole-time basis, unless the work spots are isolated, or detached from the other work area. One Dozer may be employed to cover 3 to 4 borrow areas in contiguous reaches not flung apart too wide.

3.3.9.4 *Access roads*

In certain locations where the work-spread is too wide—specialy on work on canals in desert area, one has to ensure timely supply of basic materials and other supplies necessary for operation and maintenance of equipment, and even for carriage of personnel to the work site. Adequate facilities by way of properly laid access roads, and service roads to the site of work, is a pre-requisite for such operations. Unless this is properly organised, useful working time gets lost and the machines cannot be fully utilised.

3.3.9.5 *Channels of communications*

Other Channels of communications are also equally important in the nature of telephone connections, wireless broadcasting sets—either installed in the vehicle, or separately installed at certain locations of work. In the event of some of the important items of supplies of spare parts not being readily available at site, messages transmitted through such communication system cut down the time involved in securing supplies of essential items at site and thereby reduce the downtime of equipment.

3.3.10 *Lack of incentive for the Labour Engaged on Operation, Maintenance and Repair of Equipment.*

Work with equipment can be brought to a proper level of operational efficiency, if the Operators and Mechanics identify themselves with the work and become partners with management in the entire operation. It is very necessary that the working personnel be given proper wages or else, due to negligence etc., cause the resultant handicap to production and utilisation. In the private sector, certain arrangements have come to the notice of the Committee, where the Operators work as partners with the management to the extent that the machines are supplied to the Operators at the cost of the management. The Operators look after the machines individually themselves for maintenance and repair, etc. Payments accrue to them on basis of daily work done, while deductions are made from their account in '36' monthly instalments towards the cost of the machines. The ownership of a machine like Tata Tippers, gets transferred to the Operator in the course of a period of 3 years or so. Yet the operator keeps getting an amount of Rs. 350 to Rs. 500 per month. The Operator feels devoted to the machine with full zeal and vigour so as to keep it properly maintained and without breakdowns. Of course, this may not be applicable to most of the Government operations, or Public Sector Undertakings' work; but it is amply proven by this example, that incentive of some kind, even though bonus or production etc., is essential in the interests of promoting the standard of utilisation and for boosting up production.

3.3.11 *Management of Operations*

The operational efficiency with any large scale mechanised operations with equipment, can be achieved to the required extent only if the Management coordinates the activities engaging the fleet of equipment, as a whole. The operation executives and the maintenance/repair shop heads have to work hand in hand for organising a successful operation of the working, repair and overhaul of equipment so that there is least downtime, optimum utilisation, and maximum production. It is unfortunate that on some of the work sites, there were visible signs of people working in water-tight compartments and not co-operating with each other in so far as the operation, maintenance and repair of equipment is concerned. With the decentralisation of responsibility for operation, maintenance and repairs to three different groups, it is necessary that proper coordination is organised by Management in the functional areas and responsibilities assigned to the three groups. The position may get eased if a system of weekly or biweekly meetings is introduced for solving the problems and difficulties in the overall interest of better utilisation of equipment and production thereby. Such meetings could be held periodically with the top manager, who can issue principle/policy directives at frequent intervals for smooth sailing of work.

Elaborate details in this respect have been given in Chapter 14.

3.4 Summary of Observations and Recommendations

Low utilisation of equipment is a direct result of excess of equipment over what is actually required for the job, the work-load on items of equipment varying substantially at different stages of the work or at periodical intervals, initial selection of equipment in absence of exact details of the nature of work and the best method of doing it, random additions of equipment being made to meet short-term need of the work, repair and maintenance facilities being not adequate, inadequacy of maintenance management organisation, lack of skilled staff for maintenance and operations or lack of training facilities, lack of proper planning for spare parts provisioning, poor working conditions, poorly planned haul road maintenance, retention of equipment even when not required on the job and improper management of operations.

In order to achieve better utilisation, the following recommendations are made: —

(1) All technical details relating to work be finalised in a thorough manner initially before the work on the project commences. A period of one year may be stipulated as the time between the approval of project estimates and finalisation of design details and financial estimates so that the requirement of equipment can be properly assessed in desired details based on a regular Plant Planning exercises.

(2) A clear policy about the makes and sizes of machines in different categories and makes of their power units should be laid down, at the time of first bulk purchase of equipment in the event of procurement in stages.

(3) Forward planning of work be clearly done when work is undertaken on new projects and the mode of execution of work either departmental or through private agency, be clearly decided before the equipment is purchased.

(4) Scaling of requirements of equipment should not be based on low factors of availability and utilisation. Instead adequate provisions should be made for the facilities necessary for expeditious repairs and proper maintenance of equipment and for the agency/organisation to manage this properly.

(5) A very clear view be taken initially of properly co-ordinating and integrating all resources before deciding to invest large sums of money in the purchase of equipment on the job, or making critical analysis 'CPM' Charts and 'PERT' analysis should be the scientific method of approach for work on projects.

(6) For research in methods of improvement in operation, utilisation and productivity of machines, a separate Cell for carrying out 'Time and Methods' Studies should be organised by every large scale user of equipment well in advance.

(7) Equipment should not be retained longer than necessary on projects/works. Advance planning should be made for rehabilitation/disposal of such surplus equipment. A Central Co-ordinating Agency in a State, in a Sector, in an Undertaking may be centrally assigned the work of rehabilitation/disposal of surplus equipment. Prior clearance should be taken from this Coordinating agency regarding non-availability of equipment before it is purchased from the open market.

(8) Specialisation in different phases of servicing and repairs of the equipment should be introduced by assigning separately the work of field maintenance, preventive maintenance and Section and officers under the main equipment inspection, major repairs to separate Divisions/Sections and Offices under the main equipment management organisation. This would ensure expeditious turn-over of work in each section and consequently increase available time of the equipment besides ensuring better quality in each respect. Senior and well experienced officers should personally manage and supervise the work of each section.

(9) Adequate facilities should be created for maintenance and repairs to equipment. The workshops lay-out whether for field maintenance and repairs or for centralised maintenance and repairs should be meticulously planned in advance commensurate with the load of work. Provision of hand-tools and other handling facilities, which would cut down the over-all time in maintenance/repair of equipment should be provided.

(10) Hygienic conditions must be created for proper upkeep and repairs of equipment.

(11) Planning of haul roads and their maintenance should be done with utmost care treating this subject as important as the basic Plant Planning exercise. Safety of operations and control of cycle time of operations by such mobile equipment on production jobs can be ensured by proper care being bestowed on haul road planning.

(12) Management of operation maintenance and utilisation of equipment should be so organised so that the planning and execution of the work is a smooth and coordinated process for effective control on production and economy in cost. The organisations should be well-knit for a co-ordinated effort and frictionless working amongst all levels of management on the job.

(13) An efficient maintenance materials management organisation should form a vital part in the whole organisation so that equipment is not laid off in absence of some vital supply of parts etc.

(14) Formalised training of Operators and Mechanics should be arranged. Only such persons should be assigned the operations and maintenance of equipment as are properly skilled in the trade and can contribute and be partners in proper upkeep of the machine.

(15) For optimum utilisation of equipment to result in maximum productivity of machine, a departure may sometimes be necessary from the conventional organisational set up to provide specialists to control certain process of maintenance, preventive maintenance and repairs to equipment or in creating special facilities for expedition in such work. The little increment and investment arising out of employment of persons in such a class—specialists and the extra equipment and facilities, will pay back their own cost many times over.

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CHAPTER 4

PROCEDURE, SYSTEM AND METHODS OF PROCUREMENT OF SPARE PARTS AND INVENTORY CONTROL

4.1. **Importance of the System**

How important is a proper system and method of procurement of spare parts in context of optimum utilisation of construction plant and equipment and maximum productivity thereby? A proper evaluation in this respect could be made only in terms of losses sustained in production due to down time of equipment attributable to non-availability of spare parts in time. On the other hand, in the process of providing full safeguard against eventual down time of equipment, it can also happen that the stock of spare parts get to a level, where it amounts to blocking up of capital in an unproductive manner due to comparatively lower turnover of parts in usage, and leaving an excessive stock in reserve. Such excessive stocking of parts, besides blocking up productive cash capital, results in additional loss due to heavy inventory holding costs and obsolescence costs over long periods. It is, therefore, only essential that the system or method of indenting and procurement of spare parts be such as would, besides providing proper assurance for availability of required spare parts in proper time and quantity, not result in excessive stocking or blocking up of capital investment.

4.2. **Magnitude of Problem**

4.2.1 *Situation at Different Projects*

A study made by the Committee regarding yearly stock receipts, issues and balances of spare parts over a period of 5 to 6 years, in relation to a few of the major projects, reveals that the yearly values of stock issues of spare parts are much less than the corresponding values of yearly receipts during the years. Even when the project work is tapering off to a close, the value of yearly receipts of spare parts some times exceeds the value of issues. The information that could be collected from a chosen few users of equipment is given in Appendix 4.1. In addition, this Appendix gives information regarding value of equipment added year after year, on each project. It may be seen from the figures that the value of spare parts in stock, left as balance at the end of each year, is high, when compared to the value of equipment at hand. Apparently, there has been an element of injudicious planning with respect to quantum of spare parts to be ordered, even though this may not be the sole factor to account for such a situation. It is likely that due to procedural and policy matters governing the import of spare parts, some of the critical items of spare parts are not included in the list of spare parts being procured and it is this adjunct of critical items of spare parts, which are otherwise necessarily required to supplement the existing stocks, that comes in the way of proper utilisation of available parts and consequently, results in high balance of spare parts left in stock at different intervals of time.

Such a situation also arises from unforeseen breakdowns, specially, when the new equipment is in use. It is customary to have initial supply of spare parts to cover two years running and maintenance requirements and this does not include slow-moving items. The unforeseen breakdowns resulting from accidents, inadept handling of equipment and from inherent defects in design and construction features of the machine, occassionally involve replacement of some of the slow-moving parts. Such parts also get to be listed as critical items and have to be procured in an unscheduled manner.

It is often stated by the owners of equipment that the utilisation of equipment with them has been poor due to lack of spare parts. An impression is generally given that the store rooms on the projects have almost everything except the particular part that is needed. All the same, the influence that lack of spare parts will have on production and total economy of the work in hand, or on the project, could be better assessed if we have figures for the costs of having spare parts in stock, the down-time cost and the added value cost—evaluating the loss in production by the machines when these are rendered inoperative. Unfortunately, only a very few of the projects have reliable figures for loss due to down-time and due to various reasons—waiting for spare parts for instance.

4.2.2 *Situation with One of the Major Sector*

A specific study has been made by the Committee in relation to one of the main sectors, where a fairly large amount of equipment is in use. It was observed that in spite of stocks of spare parts valued at over Rs. 200 million being available, the average utilisation of the equipment in the sector as a whole was of the order of 40% approximately. Even this figure of 40% utilisation resulted from taking into account certain cases where the equipment utilisation was of the order of 60% to 80%. If those few cases are discounted, the figure of average utilisation may be as low as 30%.

4.2.3 *Loss Due to Heavy Stock Lying Unutilised.*

The enormous amount involved viz., Rs. 200 million, would reflect the magnitude of the problem in so far as blocked capital is concerned, and the yearly inventory holding costs that would accrue. Reckoning the inventory holding costs at 12% to 15% of the value of stocks, the yearly expenditure, which is otherwise unremunerative, would amount to Rs. 25 million to Rs. 30 million, every year. Leaving aside the losses to be sustained in production due to down time of equipment resulting from non-availability of spare parts required to match the available stocks, the yearly loss of revenue itself is alarming in proportion to the cost of spare parts in stock or to be procured for gainful use of the available parts.

4.3 **Reference to a Paper Published at I.R.F. Seminar**

Since the common points of consideration would be the same for any user of equipment anywhere in the world, it is considered pertinent to refer to one of the papers published at the time of the International Road Federation Seminar held in 1969 at Chicago, U.S.A. In this paper, Mr. C. J. Haring of M/s. J. Haring Co., U.S.A. listed the following 9 points in this connection: —

1. The user should form the habit of ordering a good quantity of recommended spare parts, of the consumable type, with each new machine.

2. Should users find the availability of spare parts, locally, to be poor in their opinion, the user should be specific in taking up the matter precisely with the manufacturers involved or the distributors. As far as possible, the "total cost concept", should be the basis for purchase of equipment, if the total consumption of spare parts in the life time of the machine is to be properly evaluated in deciding the purchase price to be paid for new equipment.

3. As a user, when you receive a new machine assess properly as to who would service the components and assemblies on the machine—would the user himself organise necessary facilities in this behalf, or he would list the services of the distributor of equipment, or any other agency for this purpose? The 'unit replacement system' helps to save down time costs and ensures more production with given units of equipment.

4. Whether a private, or a Governmental user try to get as many spares as possible from the local distributors and encourage them to continually improve their repair parts service? With a given "turnover" they can afford to work on lower, reasonable margins of profit and carry more of the slow-moving parts.

In case the user feels that the parts prices are too high, the matter should be specifically taken up with the manufacturers who would be glad to explain their pricing policies. Listen with an open mind and be fair with your judgement.

5. If you consider the use of nongenuine parts, be sure to look beyond first costs; and if the manufacturers' warranty on your machine is in jeopardy, you must also consider that if you buy most or almost all of your consumable fast-moving parts from sources other than the machine distributor, you may need to pay more for the slow-moving parts (high in prices, air transportation etc).

6. Make sure that the user gets a 'Repair Parts Book' with each new machine and that the book is in a shape which makes the user understand it sufficiently well.

7. Good record keeping of total machine costs—purchase price, repair figures, operating costs and even the hours of availability—should pay excellent dividends for all users and prove invaluable in their future planning.

8. The help of important Government officials, who understand the importance of keeping the equipment operating, that is vital to the growth of country's economy—is badly needed to minimise the present delays on import licences and customs clearance.

Controversial parts that might be made locally, quickly, and of good quality, should be eliminated from licence requests, so that this argument does not contribute to the processing delay.

9. Weigh the advantages and disadvantages of bringing spare parts into your country along with machines purchased under foreign loans. Put emphasis on the consumable parts in all cases, as it is usually the lack of these that can bring the projects to a screeching halt.

The need for quoting the observations as above, has resulted from the functional aspect of the ideas involved therein. These would universally apply to all users of equipment anywhere in the world. In fact, the text of the 9 observations as above, would make recommendations that would generally be made with respect to spare parts procurement etc., by any user of equipment.

4.4 Existing System and Method of Procurement

Keeping in mind these points, the Committee have made a study of the existing system and methods of procurement of spare parts as in force with different users of equipment in the country. A broad outline of the details in this respect is given in what follows.

On all Projects/works where the size of the fleet of the equipment is fairly large, a separate Purchase Organisation is created to process besides cases of stock items and materials, all cases of procurement of equipment and spare parts.

4.4.1 *Indenting and Verification*

The proposals for procurement are initially framed by the respective Divisions of the Project/Works Departments operating and maintaining the equipment and before these requisitions are passed on to the Purchase Organisation, these are referred to the Stores Department for verifying the following details—

(i) What is the present stock position in relation to each item covered by the requisition?

(ii) What is the quantity on order against each item, which has yet to be supplied against previous orders?

(iii) What is the pattern of consumption of the item based on issues against the item in the past?

(iv) What is the issue rate of the item, in case the item has been received and issued in the past?

4.4.2 *Examination by Purchase Section*

The Purchase Organisation on receipt of the requisition refer the same to the Financial Advisor/Controller, with a view to getting necessary clearance from financial angle for processing the same. Simultaneously further examination of the requisition is done in the Purchase Section, in respect of the following points:

(1) The number of machines and their acquisition cost for which the spare parts requisition is made.

(2) The average number of working hours clocked by the machines in operation so far.

(3) The total amount of purchase of spare parts for these machines in the past.

(4) Special remarks, if any, regarding standard of performance of any of the parts which were under test and trial.

(5) Source of procurement in the past.

(6) The time in which the supplies have to be arranged—whether the demand is emergent, urgent, or of routine nature on advance planning basis?

(7) Have any items to be air-freighted?

(8) Whether any replacement Part Numbers have been given in the requisition against some of the items of spare parts?

(9) The manufacturers' Serial Nos. of the machines and their model number etc., to be quoted while placing the Purchase Order.

(10) In case any indigenously manufactured spare parts are to be procured, the particular items to be so processed, have been clearly marked or not.

(11) For imported items of spare parts, whether the details to be indicated in the Actual Users Import Licence Application have been properly given.

4.4.3 *Procurement Action*

On verification of the details as above, the requisitions are referred to the established Importers of spare parts or dealers of equipment for quotations, unless valid D.G.S. & D. Rate Contracts exist in respect of spare parts for particular makes and models of machines. In the former case, where Rate Contracts are not in existence, a press notification would be generally issued, inviting quotations.

4.4.3.1 *Against rate contract*

In respect of the items on Rate Contract, the order would be placed directly by the Direct Demanding Officer in relevant DGS&D Form for supply of the parts, on the respective Rate Contract holders, or if the total value of the order exceeds the ceiling for the amount as fixed by the DGS&D, for individual orders against Rate Contracts, an indent will be placed on the DGS&D.

4.4.3.2 *Against parallel rate contract*

In relation to orders against Rate Contracts, if there are more than one Rate Contract holder for the same item, the Purchase Organisation would either invite quotations from all the Rate Contract holders, and then decide the case for placing Purchase Orders on individual Rate Contract Holders according to the lowest technically acceptable bids; or else, if it is the experience of the Purchase Organisation and the user of equipment that the quality and standard of the parts supplied in the past by any of the Rate Contract holders, has been unsatisfactory, the orders would be placed on the Rate Contract holder giving most satisfactory service, both from stand point of quality of the goods and their delivery in proper time.

4.4.3.3 *Processing by D.G.S. & D.*

For individual requisitions whose total value exceeds the ceilings imposed by the DGS&D, the requisition would be referred to the DGS&D in a prescribed Indent Form when the DGS&D would process further according to their own purchase regulations and rules.

4.4.4 *Import Licence*

In case the spare parts are to be imported on Actual Users' Import Licence application, with all necessary details on points as listed at para 4.4.2. above, would be made and forwarded to the sponsoring authority—the Union Ministry concerned or the Department concerned, who will process it further according to the Import Trade Control policy regulations for getting the sanction to the release of foreign exchange in the first instance, and then processing the same for getting an import licence issued by the C.C.I.&E. or any other Import Control authority concerned.

4.4.4.1 *D.G.T.D. clearance of banned/restricted items*

Some times, the import licence applications include certain items, like Bearings, Seals, Fan Belts, Gaskets etc., which are otherwise classified as 'banned/restricted items'. The sizes of these items generally required for heavy earth-moving machines, are only partially covered by the indigenous manufacturers in the country; hence, it becomes necessary to import these items. The D.G.T.D. who have to, in the first instance, scrutinise the list of goods to be imported and give necessary clearance from indigenous angle, do not clear the import of these items unless the actual users have already advertised through Indian Trade Journal, the demands in respect of these items and any other 'banned/restricted items', giving clearly the description of parts required, the particular part numbers relative to the machines for which the parts are required, and the quantity to be procured against each item. Most of the users of equipment do not generally follow this practice of advertisement, which results in delay in the procurement of the imported parts. It would be only proper if each user draws up complete lists of such 'banned/restricted items' in relation to individual items of equipment, prepare a complete and detailed inventory of these items, and issue general advertisements calling for quotations from indigenous manufacturers. Such an exercise can be done once every year. If any suitable offers are received from indigenous manufacturers, in respect of any of the items included in the lists so prepared, these could be deleted from the list of goods accompanying the Actual Users' Import Licence applications. In the event of any or all items covered by such lists being not available from the indigenous manufacturers, or no quotations being received from them within the specified notice period, mentioned in the Press Notification, the fact could be suitably stated while forwarding the import licence application, so that the D.G.T.D. are in a position to give necessary clearance for import of the required items.

4.4.5 *Procurement from Open Market*

The steps generally involved in procurement of spare parts, may however, be listed as follows:—

1. Preparation of requisitions.
2. Placement of Indents.
3. Invitation of Tenders.
4. Scrutiny of Tenders.
5. Placement of Orders on successful bidders with definite delivery schedule.
6. Expediting suppliers for supply of goods.
7. Review of deliveries against orders.
8. Possible cancellation of orders due to delay in supplies, or failure on part of the supplier to fulfil the purchase contract, including cases of short supply of spare parts and partial cancellation of orders.

These are the main functions performed by the respective purchase organisations whether attached individually to a major equipment user, or the Central Purchase Organisation coordinating the work of purchase on behalf of number of small users of such equipment.

4.4.6 *Organisation*

The Organisational set-up with most of the major users of equipment in relation to such purchases is given in Appendix 4.2. The organisation is headed by a Chief Purchase Officer, or a Purchase Officer, under the General Manager or Chief Engineer of a Project, or under a Materials Management Officer, under the Control of the Managing Director of a Public Sector Undertaking.

4.4.6.1 *With Projects*

In certain cases, depending upon the size of the fleet of equipment in use, separate Purchase Organisations are not created for individual works. The purchase work is generally done by a Central Purchase Organisation on behalf of a number of such smaller works/Departments. In that Central Purchase Organisation, the system followed is of the same nature as described above.

4.4.6.2 *With Public Sector Undertaking*

In the Public Sector Undertakings, however, where the procurement of spare parts etc., is not necessarily made through the D.G.S.&D. or against their Rate Contracts, there are separate Purchase Organisations, both at the individual project level and at the Central Headquarters, which coordinate with a number of such projects in different areas and locations, in the event bulk purchase of spare parts is to be made for identical items of machines working at different locations. There are instances where such Purchase Organisations of the Public Sector Undertakings at Central Headquarters have entered into separate Rate Contracts with established importers/dealers of equipment for supply of spare parts. Generally speaking, the terms and conditions of the Rate Contract, as finalised by these organisations, are more or less identical to the terms and conditions of the Rate Contracts as finalised by the D.G.S.&D. There are only minor departures from the details of the Rate Contracts as finalised with the D.G.S.&D. mainly in relation to payment terms etc.

4.5. **Functioning of the Present System and Measures for Improvement.**

Following are the general observations of the Committee, with regard to the functioning of the system/method of procurement of spare parts etc., as followed by different users of equipment.

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4.5.1 *Indenting of Spare Parts*

It is unfortunate that the preparation of requisitions, which makes the basic material for the indent for procurement of spare parts, is generally made (in most of the cases) by very junior persons of the staff.

4.5.1.1 *Responsibility of indenting*

In some cases, this originates from senior Mechanics/Chargemen. The calibre of persons of this status being what it is at present, the requisitions fail to give realistic assessment of requirements. Unless the requisitions are prepared based on the history of performance of given makes and models of machines with the help of History Sheets/History Cards, these cannot be expected to serve any useful purpose. No wonder why, in spite of huge stocks of spare parts built up at different project sites, certain items of spare parts are still not available, even if these may fall in the category of 'fast-moving parts', whose consumption would be substantial and repetitive in nature. The framing of such requisitions must necessarily be the responsibility of an Assistant Engineer/the Sub-Divisional Officer, or a Graduate Engineer-Supervisor, who have the requisite experience in operation, maintenance and repair of the machines, or who are personally responsible for maintaining the History Record of performance of the machines. If economy is to be really entailed to the function of indenting, procurement and scaling down the requirements of spare parts to the proper levels, it is high time that the work of preparation of requisition for spare parts be assigned to competent persons only, not leaving it to the lower staff who may have the necessary skill for repair work, but not the scientific mind to assess or plan the requirement methodically commensurate with the age and condition of the machine.

4.5.1.2 *Checking of indents*

The officer in charge—generally of the Divisional rank, Executive Engineer, who ultimately places a formal indent with the Purchase Organisation directly or through the Superintending Engineer/Superintendent works, has to discharge his responsibility by scrutinising the total demand in a requisition in relation to unit requirement of individual items of parts for a given machine, the pattern of consumption of the item in the past, the stage in the service age of the machine, the expected out-put in operational hours by the machine over a predefined period in the future for which the requirement is being planned (related to lead time for procurement), the classification group in which the individual items would fall—the A.B.C. analysis by virtue of value of the items, and the total value of purchases of spare parts so far made for given items of equipment, in consultation with the inventory control cell.

4.5.1.3 *Need for an inventory control cell*

Here again, it is the observation of the Committee, that in the normal course, even though some care is exercised regarding the size of the indent to be made, meticulous check is not exercised on the points mentioned above. The Divisional Engineer, who is mainly the Indenting Officer, has to understand clearly the Inventory Control System and implement it in practice. There is dire need of separate Inventory Control Cells being opened, after the persons operating on the work in that Cell have been fully trained in this field.

4.5.2 *Indents with D.G.S.&D.*

Quite often, the indentors do not furnish all the information asked for in the prescribed indenting proformae which are required to be filed and forwarded to the D.G.S.&D. lot of delay is involved in processing such indents for procurement due to incomplete details being received from the indentors. It would be a paying proposition to introduce a Check List System by the D.G.S.&D. The Check List should clearly specify the items of information to be checked for completeness of the indent before it is forwarded to the D.G.S.&D. or to the Purchase Organisation. Once the indent is accompanied by the Check List duly verified, the D.G.S.&D. or the Purchase Organisation may not have to delay the procurement action on the indents.

4.5.3 *Initial supply of Parts*

4.5.3.1 *Recommended parts*

While it is admitted that the user should form the habit of ordering a good quantity of recommended spare parts of the consumable type (the fast-moving items) with each machine, it is very important to clearly understand the precise meaning of the comprehensive term "recommended spare parts", What are these recommended spare parts, and who makes the recommendation in this behalf? About 15 years ago, the answer to this question could have been that the distributors of equipment in India (when almost all the equipment was of imported origin), where to give the details in respect of items to be purchased with the machine; and this was the actual practice. Most of the users of the equipment, however, came to face a situation resulting from such recommendations, where almost 30% to 40% of the recommended parts, initially supplied with the machines, were left over as slow-moving parts, which were not put to use for a period of first 2 to 3 years of the service life of the machine.

4.5.3.2 *User to make assessment*

It is essential for the manufacturers of equipment to develop the recommended lists of spare parts to be initially supplied with the machines in a realistic manner in consultation with experienced users of equipment in the country. However, the user should make himself responsible for making a proper assessment of the initial requirement also.

There is no doubt, that with the technological advancement in the manufacture of items of construction plant and equipment, the machines do get obsolete with time; but the main principle to be imbibed or to be guided by is that the identity of the parts in various systems on the machine has not changed much. Taking into consideration the particular use of the spare parts, the user can generally cash on his past experience in the matter of determining as to how frequently any parts would require repairs or replacement and which would be the parts which would be of this nature. It is only a matter of cashing on past experience and utilising it to the best advantage in making a proper assessment of requirement of parts over a given period of time in the operational life of equipment.

4.5.3.3 *Recommended parts for indigenous equipment*

Even while the indigenous manufacture of equipment has been developed in the country, it has taken fairly long time for the manufacturers to publish the recommended lists of spare parts for individual models and makes of machines manufactured by them. Even those lists are compiled on rough reckoning basis. The service organisations of the manufacturers have seldom taken stock of the actual consumption of different items of spare parts for the particular machines marketed by them, and therefore, the recommended lists of spare parts are not framed on realistic basis.

Most often, the users of equipment are heard to be saying: "It is the first time we are using this equipment, and therefore, we had to be guided by the recommendations of the suppliers of equipment in framing the first requisition for supply of spare parts with the machine. It is the supplier who has supplied the parts which are not moving fast and have gone into dead stock in the stores'. Such indication of helplessness on part of the users of equipment may legitimately be a cry in the distant past; but in context of the present day use of such equipment, this cannot be a tenable reasoning or argument for selecting parts which are not used over long periods. This is not the end of the misery arising out of stocking of slow-moving parts for long periods for new machines. What is more disturbing is the nonavailability of some of the vital parts of fast-moving nature which are not available in adequate quantities commensurate with the need of the machines in use, not only during the initial period immediately after first commissioning of machine but also in its subsequent service life.

Notwithstanding the fact that certain slow moving parts are bound to creep in as it may not be possible to identify and anticipate clearly all requirements by the users (even those who are maintaining data scientifically), it is essential to exercise a proper check at competent levels to screen the recommended list of spare parts given by the manufacturers/their accredited agents. This will go a long way in reducing the stock of relatively slow moving parts.

4.5.3.4 *Procurement procedure—Aid to import substitution*

To permit import substitution relative to items of spare parts, the purchase/procurement organisation should include a competent senior officer, who would develop lists of such parts as can be conveniently got manufactured in the country. He will also develop a list of manufacturers of spare parts through the process of press notifications inviting tenders for identified items of parts, by keeping a close liaison and co-ordination with the Central Coordination Cell mentioned in para 6.3.2. Chapter 6, and also by using the information circulated or transmitted by the Coordination Cell from time to time regarding names of the manufacturers and the items of spare parts being manufactured by them. His activities would be more in the nature of research and development for the purpose of increasing the scope of indigenous manufacture of spare parts.

In this process, it will be possible to locate initially some of the prospective manufacturers. Placement of trial orders on them for such parts developed for the first time, their test and trial by installation in the machines until the product gives satisfactory/proven performance, will be the next step to be taken.

Though in accordance with the normal rules and procedures, as are in vogue with the Government Departments, the suggested practice may not be a warranted one, but in the overall interest of import substitution and savings in foreign exchange, this will be a worthwhile exercise to perform. In fact, this will help to get quicker some critical items (through indigenous sources) which are otherwise to be imported.

An average manufacturer is principally attracted towards indigenous manufacture of spare parts by the bulk and size of the orders he receives. The requirement of individual projects/users being rather small, most often, it is difficult either to induce the manufacturer to undertake the manufacture of the required items or else the price asked for by him therefor is exhorbitant. It requires a great effort to convince the local finance to accept the proposal for placing even trial order for manufacture of few numbers of a given part on that manufacturer. One method to get over this situation is to pool the requirements of a number of users in respect of such items, so that the bulk and size of the order is acceptable to the manufacturer at reasonable prices. Such pooling of requirements could be conveniently done atleast in respect of users of such equipment in a sector as a whole, or within a State. The Central Mechanical Unit in Irrigation and Power Sector in each State performs this function in relation to river valley projects, while other Coordinating Cells or agencies in individual sectors also work on these lines.

Moreover, functionally, the Central Mechanical Unit or the Coordinating Agencies in other sectors would coordinate with each other through the proposed Central Coordination Cell in the CW&PC. Pooling of requirement of a number of users in different departments/sectors would make the proposition for manufacture of identified parts more attractive and economical, price-wise.

Hence, the Central Mechanical Units or Coordinating agencies should individually and mutually follow programme of import substitution and development of indigenous manufacture of parts; but due to large concentration of equipment on construction projects and in certain other production jobs, suitable officers be nominated for initiating action to identify the items of spare parts to be manufactured as also the manufacturers who will produce these to the acceptable standard of technical specifications etc.

Wherever necessary, local orders may be issued by the administration concerned for authorising the suggested approach for developing indigenous manufacture and procurement of indigenously manufactured spare parts from identified sources/manufacturers.

Yet another more effective method of approach to this problem is to induce the dealers/suppliers of equipment to plan the manufacture of spare parts, as they would know more clearly the size of requirement of parts of all those equipment owners to whom the equipment was supplied by them. Moreover, they would also have a proper understanding of the technical specifications, metallurgy and measurements of the parts to be manufactured. It would be easier for them to get the working drawings, specifications and other technical details from their principals. The main incentive to be given is to arrange for clearance from the Industrial Development Department for import of working drawings from their principals abroad. Even if royalty charges etc., are involved, subject to these being in accordance with the standards, norms and conditions defined by that Department, these could be arranged to be paid if the requirement of parts involves a substantial turnover in value. A fair amount of discretion and judgment would have to be used in taking the decisions for setting the specifications and measurements of the parts to be manufactured after obtaining details and metallurgical analysis from our own laboratories, or to import the working drawings from the principals abroad. It is gratifying to note that the principal suppliers of imported equipment in India have gradually undertaken to get a fairly large number of imported items of spare parts manufactured in the country. Parallel action by the projects or Central Coordinating Agencies for indigenous manufacture of spare parts should be taken mainly in relation to such items as are not covered by the suppliers of equipment through their planning, or programme.

4.5.4 *D.G.S. & D. Rate Contracts for Spare Parts*

4.5.4.1 *Rate contracts*

Since the items of spare parts for construction plant and equipment—mainly earthmoving machines, are proprietory in nature, no useful purpose would be generally served in inviting open tenders every time the items are to be purchased. After all, only one supplier or distributor of equipment would be in a position to supply the required parts, either from his own stocks or after importing these from his principals abroad. In order, however, to decide on the rate structure of the prices to be paid for spare parts of a particular make, the D.G.S. & D. finalise Rate Contracts with the accredited agents/dealers of equipment, fixing up the prices in relation to the manufacturers' prices. Such Rate Contracts were valid for a period of one year in the past, but as of now, they are valid up to 2 to 3 years period.

4.5.4.2 *Direct demanding officers*

The D.G.S. & D. have also enlisted officers of the Central Government Departments, State Governments, and even Public Sector Undertakings as "Direct Demanding Officers", who can place supply orders on the Rate Contract holders for supply of the items covered by Rate Contracts in relation to items of spare parts for given makes and models of machines. (This saves a lot of time otherwise involved in inviting quotations, deciding the tenders and placing of the orders). The orders are placed in the supply order forms prescribed by the D.G.S. & D.

4.5.4.3 *Parallel rate contracts*

In certain cases where items of spare parts of general nature, like Hoses, Fan Belts, Gaskets, Seals, Bearings etc., etc., are supplied by some of the primary manufacturers to original equipment manufacturers, parallel Rate Contracts are entered into by the D.G.S. & D. with the accredited Agents/Distributors in India of such parts on behalf of the primary manufacturers abroad. The individual items' prices in respect of such parts supplied by the primary manufacturers are lower than the prices in the Rate Contracts with the accredited dealers/distributors of equipment, on behalf of original equipment manufacturers abroad. The placing of orders in supply order forms on the parallel Rate Contract holders is similar in manner to the placing of orders on the principal Rate Contract Holders.

4.5.4.4. *Delays in supply against Rate Contract order.*

During discussions, the Members of the Committee had with different users of equipment in the country—the Direct Demanding Officers, a feeling of dissatisfaction was sounded by them with regard to operation of the Rate Contracts in context of the supply orders placed by them on the Rate Contract holders. The main difficulty experienced is that the supplies are generally delayed (in some cases inordinately) by the suppliers.

4.5.4.5. *Reasons for delay.*

Such delays may be attributed to the following reasons:—

1. Inadequate allocation of foreign exchange to the R/C holder for importing spare parts against his own import licence.
2. Validity of the Rate Contract having expired.
3. Revision of prices under the Rate Contract being under settlement with the DGS&D.
4. There being a heavy back-log of orders at hand with him and his discretion in ascribing a national priority to the supply orders of individual indentors, and
5. Difficulties in imports.

4.5.4.6. *Possible remedies.*

Though the Direct Demanding Officers and the DGS&D have by now stream-lined the procedure for finalisation of supply orders and rate contracts to meet the eventualities arising out of '1', '2' and '3', an average Direct Demanding Officer has found it difficult to evaluate precisely the reasons referred to in '4'. Perhaps, the supplier accommodates the huge backlog of orders at hand with the hope of getting enhanced foreign exchange allocations for import of spare parts. An indication by him initially of his inability to supply the required parts against his own import licence would enable the D.D.O. to make arrangements for processing AUIL application.

The Direct Demanding Officers have generally expressed the feeling that the Rate Contract holder is influenced by his mental attitude regarding the rate structure of the prices included in the Rate Contracts. His main attempt is to get better return on his investments; and he accomplishes this by selling some items of spare parts to others who are not Direct Demanding Officers. Even though in the matter of purchase management, the "reciprocity aspect" makes a vital factor, it is evident that in spite of prolonged deliberations involved prior to finalisation of the DGS&D Rate Contracts, the seller agency or the rate contract holder, pays scanty respect to the same.

Even though a proper tangible appraisal cannot be made of these aspects, the Committee considers that it may be possible for the DGS&D to go to the root of the problem for devising certain practical approach for more satisfactory performance on part of the rate contract holders even if some concessions have to be granted. The sacrifice that may be made through the total value of these concessions may more than off-set the idle-time costs of equipment which remain unproductive for want of some of the parts covered by the Rate Contracts.

4.5.4.7. *Difficulties in Ordering against Rate Contract.*

A case has come to the notice of the Committee where spare parts were purchased through a supply order against a valid Rate Contract. The list of requirements of spare parts having not been prepared with meticulous care technically without regard to details at para 4.4.2. the size of the supply order in terms of total value thereof was known only after the supplies were physically completed and that too on specific reference to the supplier. It was only then observed that the spare parts procured in one lot, amounted to about 2/3rd of the value of the machines, while the machines had hardly been in operation for about 5000 hrs. against a scheduled life of 16000 hrs. The fact of over indenting or wrongful scaling got revealed on receipt of price lists. It was too late in the day for the purchaser to realise that the total value of the indent was much out of proportion to the value of equipment when the supply order was placed.

Normally, the equipment dealers should be prudent in recommending purchase of spare parts only to the extent these would be required for their machines with any user (with due consideration to the condition of the machine, its age in service life etc., etc.). Some of them, however, unscrupulously indulge in sales gimmicks and try to palm off the available parts to the equipment users. As a safeguard against such eventualities, it would be advisable that quotations are invited by the purchaser from the rate contract holders before a supply order is placed. This would help the purchaser in making a clear estimate of the total value of the order to be placed. By this process, he will also be able to spot out the individual items of high value and review the quantities against each, so that these are commensurate with his requirement.

If this is not done, the purchaser would get to know of the prices only on receipt of the Debit Note from the Pay and Accounts Officer concerned since the consignee invoices or despatch notes issued by the suppliers of parts, most often do not include unit prices or total value of the items of spare parts covered thereby.

Admitting that every user of equipment would necessarily be careful in future in scaling his requirements of spare parts in a proper manner, it will be helpful if a price list of goods is made available to him by the supplier within 15 days of the placement of the supply order. In any case, the supplier must indicate itemised prices of spare parts in the consignee's copy of invoice or despatch note. This will help in timely finalisation of issue rates of individual items (which are otherwise arbitrarily fixed in absence of priced lists of goods) and thereby avoid any subsequent readjustment in Stores accounts and repair expense account.

The D.G.S. & D. may take a view on this matter and issue instructions to the Rate Contract holders that they should send to the Direct Demanding Officers placing the order, one copy of the list of goods accompanying the supply order duly priced within 15 days of the placement of the order; and also that the invoice accompanying the consignment of spare parts supplied to the Direct Demanding Officer should invariably include itemised prices of all items of spare parts included therein.

4.5.4.8 *Difficulties in ordering against parallel Rate Contracts.*

With regard to the parallel Rate Contracts, it has been the experience of a number of users that the supplies are either extra-ordinarily delayed for long periods, or the quality of some of the items supplied is not up to the required standard. While there is no doubt that there will be a substantial saving to the users of equipment if the prices of items covered by the parallel Rate Contracts are comparatively lower than the corresponding items covered by the principal Rate Contracts, it is difficult to contend with a situation where goods of substandard quality are received which jeopardises the functional operation of the equipment as a whole or in some cases they fail to supply the parts vitally required to Commission the machines. Moreover, it is well known fact that the principal Rate Contract holders do not take a sympathetic attitude towards users of their equipment, who take supplies of parts from the parallel Rate Contract holders whenever the user faces breakdowns on the equipment. In some cases, certain claims arising out of technical defects in some of the machines, are rejected on the plea that the original manufacturers' parts were not used on the machine. In addition, whenever certain parts, not covered by Parallel Rate Contract are required by that user, the principal Rate Contract holder of the equipment distributor, takes an attitude of indifference, may be even out of sheer spite. This is nothing new; it happens all the world over.

For obvious reasons, mainly from the financial angle and audit angle, the DGS & D have not been able to reconcile themselves with the position of dispensing with parallel Rate Contracts. It is, however, gratifying to note that they have given Direct Demanding Officers the choice to buy from one or the other Rate Contract holder items of spare parts they would like to. It is for the Direct Demanding Officer to satisfy himself that he is justified in ignoring the lower prices against the parallel Rate Contracts due to strong reasons—specially those relating to unsatisfactory performance on part of the parallel Rate Contract holder or of the parts supplied by him.

4.5.4.9 *Validity of rate contract.*

The Direct Demanding Officers have also experienced serious difficulties when the validity period of a Rate Contract expires and a new Rate Contract is not finalised in proper time by the D.G.S. & D. before the expiry of the validity date. The Committee of Ministers constituted by the Ministry of Irrigation and Power (Government of India) to recommend measures for elimination of delays in procurement of construction equipment and spare parts required for Irrigation and Power projects, had made a recommendation as follows, in this respect:—

> "2(i) D.G.S. & D. Rate Contracts for import of spare parts should be finalised in good time before the period of validity of the previous Rate Contract expires."

This recommendation has been accepted by the D.G.S.&D., and it is reasonably hoped that the Direct Demanding Officers would not be faced with odd situations experienced by them in the past when valid Rate Contracts ceased to exist for some time.

4.5.4.10. *Rate Contracts of indigenous items.*

The Direct Demanding Officers have often complained about the quality of the indigenous spare parts supplied against rate contracts. The poor quality of the indigenous product is sometimes attributable to lack of proper facilities with the rate contract holder/his principals for manufacture of such parts. Most often, the rate contract holder is not the manufacturer. The Committee feels that before rate contracts for such items are entered into, the quality of the products, the facilities for manufacture thereof, the research and development facilities etc., etc., should be arranged to be properly evaluated atleast in respect of high value items.

Some of the major users of equipment can be associated in tests and trials of the parts before these are listed on rate contract.

In order to determine the extent to which the individual D.G.S.&D. Rate Contract holders were able to market the particular items of indigenous spare parts (amongst the Direct Demanding Officers), the Committee took up the matter with the D.G.S. & D. for getting the figures of drawals against individual Rate Contract holders for supply of indigenous spare parts for various makes of earthmoving and construction equipment for the period 1969-70 and 1970-71. The following indicates the information as received:—

STATEMENT OF DRAWALS

	Name of R/C holding firm	R/C No. & Date	Stores	DRAWALS	
				1969-70	1970-71
	1	2	3	4	5
				Rs	Rs
1	M/s. Greaves—Cotton, Bombay.	1 Proj/RC-8036/Indg/Undercarriage/ GC/III/2479 dt. 27-2-69. 2 Proj/RC-8085/Indg/ Under carriage/ Cat/GC/III/2556 dated 31-5-69	Under Carriage Parts	3,64,160	40,360
2	M/s. Track Parts of India, Kanpur	Proj/RC-8036/Indg/Under Carriage/TPI/III/2478 dt. 27-2-69	Under Carriage Parts	19,13,850	10,67,576
3	Aeicorp Pvt. Ltd., Calcutta	Proj/RC-8199/Indg. Spares/APL/ III/2726 dt. 29-12-69.	Bolt, Nuts, Brake Linings, clutch facing, Oil Seals etc.	..	1,00,090
4	M/s. Components & Machinery Corp., Calcutta.	Proj/RC-8199/Indg. spares/CMC/ III/2727 dt. 29-12-69.	-do-	..	53,897
5	M/s. I.A.C., Calcutta .	Proj/RC-8199/Indg. spares/IAC/III/ 2731 dt. 31-12-69.	Radiator Cores & Radiator Assembly	..	5,860
6	Voltas Ltd., Bombay . .	Proj/RC-8199/Indg. Spares/VL/III/ 2902 dt. 24-7-70.	Oil Seals	..	46,373 (for 8 months)
7	-do-	Proj/RC-8369/Voltas/TATA P&H/ III/3008 dated 23-10-70.	Tata P&H Parts	..	19,89,243 (for 5 months)
8	M/s. T.E.C. New Delhi. .	Proj/RC-8373/Indg/Under Carriage/ TEC/III/3027 dt. 31-10-70.	Under Carriage Parts	..	24,15,524 (for 5 months)
9	M/s. Voltas Ltd., Bombay. .	Proj/RC-8387/Indg/Filter/Voltas/III/ 3063 dt. 30-11-70.	Filters	..	17,554 (for 4 months)
10	M/s. I.A.C., Calcutta. .	Proj/RC-8387/Indg/Filter/IAC/III/ 3064 dt. 30-11-70.	Filters	..	8,482 (for 4 months)
11	M/s. Componenets & Machinery Corp. Calcutta.	Proj/RC-8387/Indg/Filter/CMC/III 3065 dt. 30-11-70.	Filters	..	5,980 (for 4 months)
12	M/s. Aeicorp Pvt. Ltd., Calcutta.	Proj/RC-8387/Indg/Filters/APL/III/ 3066 dt. 30-11-70.	Filters		829 (for 4 months)

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It may be seen that during the year 1970-71, the drawals were below a total of Rs. 60 lakhs only.

The TECED Association who have since developed a Trade Directory of indigenously manufactured spare parts for different makes and models of earthmoving machines, have however, reported that the sales of indegenous spare parts during the year 1970-71, was of the order of Rs. 3.5 crores. Apparently quite a large number of items indigenously manufactured, are not borne on DGS&D Rate Contracts and many a user of equipment has gone directly to the dealers outside the Rate Contract particularly because of his not being a Direct Demanding Officer, or in some cases, the supplies being to private parties/Public Sector Undertakings.

It has also been studied with interest that against some of the Rate Contracts for indigenous spare parts, the drawals for the year 1970-71 have been very small. It perhaps, remains to be seen as to how important the items of Rate Contract are? If hardware items alone are included, the users generally go out for such purchases from elsewhere, and not necessarily against the Rate Contract.

4.5.4.11. *Review of performance of rate contracts based on annual drawals.*

The low figure of value of annual drawals against a rate contract may also some times be due to serious draw backs in the quality of goods and rather unsatisfactory service of the rate contract holder. These reasons make considerations of great consequence to an equipment user. It will therefore, be helpful if the DGS & D introduces a system of review of performance of rate contracts based on value of annual drawals, so as to determine (if the drawals are below a certain expected minimum for such reasons only), if the rate contract be sustained in operation or it be terminated.

4.5.5. *Difficulties in Imports.*

4.5.5.1. *Delays in emergency purchases through import due to ceiling fixed.*

Some times, a few critical items of spare parts have to be air-lifted so that the machines under breakdown, otherwise essentially required to be on the job to meet the pressing needs of a pre-determined schedule of production can be expeditiously repaired for use on the job. The values involved being rather small, certain sanction to the release of foreign exchange cannot be issued against US AID Loan, or any other Credits etc., and consequently, free foreign exchange is utilised for purposes of certain imports. Even though the Import Trade Central policy does provide for such imports without a cumbersome procedure being followed, the monetary ceiling by way of value of such imports being Rs. 10,000 only, it becomes difficult to arrange for import of some of the essentially required items without getting separate sanctions for release of foreign exchange, etc., due to the value of the items being much above the amount of ceiling fixed for this purpose. This delays the imports of the parts and the emergent situations cannot be met within the manner otherwise desired.

At the moment, 0.1% as emergency spares can be imported annually for individual pieces of equipment in relation to its capital cost. For construction equipment which is highly breakdown prone and has relatively short economic life, this amount was much too meagre and even at times the cost of air-freight of a critical item exceeds the above value. The Committee was, therefore, of the opinion that breakdown prone construction machinery has to be treated on a separate plane and for this group of equipment, the limit should be enhanced to atleast 1% of the value of same make and model of equipment in use in a particular project/industry. For example, if the cost of a LW-35 Dumper is about Rs. 10 lakhs, 0.1% of Rs. 10 lakhs is Rs. 1,000. The cost of the most of the individual critical pieces of parts exceeds the above value by many folds. If in a given project, there are ten Dumpers of the same make and model costing Rs. 10 lakhs each the value of 1% makes Rs. 1 lakh only and for a group of 10 machines, annually Rs. 1 lakh worth of emergency spares is not a high figure.

4.5.5.2. *Delays in clearance of consignments at customs.*

In so far as the consignments received at the sea ports are concerned, the description of the items and their commonality to the automobile parts also puts to question the bonafides of imports of certain items of spare parts. This is particularly connected with the import of spare parts for Dumpers which are classified as "Transport Vehicles". Here again, there have been cases where the sponsoring authorities have to make a special effort to issue letters of explanations, or certificates of a particular type to satisfy the customs authorities about the bonafide nature of the imports. Perhaps, the Import Trade Control policy has to make suitable clarifications in relation to import of spare parts of particular items of equipment, specially used on River Valley Projects, and in the Mining Sector. This would help avoiding delays in clearance of consignments at the sea ports.

4.5.5.3. *Pilferages.*

It also happens occasionally that on arrival of the consignments of spare parts at sea ports, certain vital items, like Bearings, Seals etc., get lost or pilfered. While the Committee would not like to give any comments which may cause a controversy to arise, it is evident that better security arrangements are called for to be introduced at the sea ports if such losses and pilferages are to be guarded against. From the stand point of equipment users however, certain safeguards could be introduced by providing a skeleton staff at the ports of import of spare parts, so that the consignments are cleared immediately on their arrival at the port. Such staff would also include the security guards.

4.5.5.4. *Remedies against pilferages.*

Some of the projects/States and the Public Sector Undertakings have posted Liaison Officers at some Ports where their consignments are received. This has generally resulted in timely clearnce of the consignments of parts and vouch safed the security of the consignments. Yet in case of some of the River Valley Projects, such proposals for creating Liaison Organisations on their behalf or on behalf of the State to which they belong, have not found favour with the sanctioning authorities.

The total expenditure in creating such liaison establishments would amount to be fairly small compared to the total saving that will otherwise accure in terms of value of the parts lost and the value of the total loss in production due to continued down time of the machines which canont be repaired for want of the pants so lost. Additionally, this would save substantial amounts of foreign exchange which would be otherwise involved in importing the spare parts for the second time. The loss in foreign exchange arises mainly due to the fact that the Government consignments are generally not insured and most often these are supplied on F.A.S. basis only.

It may, perhaps, be prudent to have such Liaison Officers deputed, on behalf of indivdual States or Central Purchase Organisations of States so that he could work on behalf of more than one equipment owning authority in the State and thereby reduce the financial burden accruing to a single project or the equipment owning authority. Cases are not rare to quote where the machines had to await some critical and vital parts for over two years because the same category of items of parts were pilfered or stolen from imported consignments more than once from the Indian Ports. It is considered most essential that such arrangements be organised under the Central Mechanical Units in the Irrigation and Power Sector of individual States, or in relation to the Public Sector Undertakings by the respective Departments.

4.5.5.5. *Loans/Credits.*

The procedural time involved in issuing sanctions to the release of foreign exchange for import of spare parts under particular Loans/Credits, the subsequent opening of the Letter of Credit after obtaining a "Letter of Commitment", and a "Letter of authorisation" from "competent authority", being fairly large, it occasionally happens that some of the consignments of imported spare parts await shipment from the ports abroad due to expiry of the validity period of the Loans/Credits. It is considered that such a position can be clearly foreseen at the time of the issue of import licences and necessary care taken to ensure that the validity of the period of the loan/credit is suitably extended.

Occasionally, the suppliers abroad who have to export the parts against orders from their agents in India, delay the exports when their hands are full with orders from other consumers in their country, or other countries. In such a case, the exports may be so much delayed beyond the normally required time that these cross the validity period.

To accommodate cases of the above type, the Union Ministry of Finance and the respective loan giving authorities could jointly consider to make a stipulation in the conditions of the loan/credit to the effect that a certain period of grace would be allowed for delayed supplies by the manufacturers/exporters abroad. This is suggested as '6' months, subject to Import Licences being issued '4' months before expiry of validity period.

4.5.5.6. *Wrong supply of parts against imports.*

In some cases, foreign manufacturers of spare parts have been supplying "inapplicable parts". Such parts are suitable for later models of equipment marketed by the manufacturers while the purchaser in India has an older model in use. Normally, the agent/distributor of equipment in India should clearly define the model number, serial number etc., of the machine for which the parts are being ordered by him on his principals; however, the wrong supplies have occurred in spite of this. The net result is that in spite of the parts being received, the consumer cannot use these for commissioning the sick machines.

Moreover, the purchaser in India has to arrange for a fresh import licence to get the correct supply and simultaneously arrange for an export licence for returning the parts to the principals abroad. The value of such imports being rather small, in any case below the minimum value of imports allowed/permissible under the US AID Loan (Generally most of the import of spare parts are made from U.S.A. against US AID Non-Project Loans), the fresh imports are to be made against free foreign exchange.

One way to remedy the situation would be to make a mandatory stipulation for the list of goods to indicate in clear terms the particulars of make, model and serial number of the machines for which spare parts are required. Simultaneously, there may be a stipulation made in the orders placed on the importers/suppliers, stating clearly that in the event of wrong supplies being made by them or their principals, it will be their responsibility to arrange with their principals to despatch replacement parts free of cost while the wrong supply would be arranged to be re-exported at their own cost in due course of time and not before the replacement supplies are arranged.

4.5.5.7. *I.T.C. Policy.*

The matter regarding delay in imports of spare parts—mainly the causes attributable to the Import Trade Control policy etc., has been dealt with in details by the Committee of Ministers constituted by the Ministry of Irrigation and Power, Government of India, to recommend measures for elimination of delays in procurement of Construction Equipment and Spare Parts required for Irrigation and Power Projects. The recommendations made by that Committee generally cover the remedial measures necessary which have since been adopted by suitable revision of the I.T.C. policy. Hence, these would not be elaborated, any further.

4.6. **Factors Considered for the System.**

The elements or factors which would help to establish the system or the method of purchase scientifically, would be; (a) a proper inventory Control system and (b) backed by an organisation manned by properly trained and qualified personnel.

The Inventory Control System is a science by itself and a great deal of attention has to be paid in organising it. This system which would be dealt with in details in the later portion of this Chapter would broadly cover the following:—

(a) Specific detailing of requirement of spare parts in proper relationship to the yearly work-time table of the machines, the progressive age of the machine in use, the consumption pattern of important items of spare parts in different systems of the machine.

(b) Identifying the specific sources of supply of spare parts within the country and abroad for given items of equipment.

(c) Making an assessment of the lead time involved—from the time a requisition is initially prepared, to the time the spare parts are available within the country.

A proper Organisation means (a) Setting up the Purchase Organisation, and (b) Laying down the purchase rules and procedure (The Purchase Manual).

In setting up the Purchase Organisation, and laying down the purchase rules and procedures, or preparing a Purchase Manual, there are some common considerations which have to be defined before detailed observations in this regard can be made.

4.6.1. *Need for proper organisation.*

The purchase organisations are mainly responsible for processing the purchase requisitions or indents for procurement of spare parts so that the required items are physically received in proper time. This alone can provide for necessary insurance against down time of equipment. What is important however, is that quantitatively the supply should be adequate to meet the requirements of maintenance and repair. This can be achieved only to the extent of indentors' competence in properly scaling out the requirements. Technical scaling of requirements involves integrated consideration of the conditions of work, pattern of work, population of like items of equipment, repair and maintenance facilities available, the age of the machine, the annual working hours and the lead time involved in procurement. The purchase organisation has, therfore, to be assisted by the equipment operatives in framing the indent properly, based on a proper technical scale of requirement.

Where a Central Purchase Organisation coordinates with a number of smaller projects, the requisitions and indents are similarly processed by clubbing the demands together for spare parts for like/identical items of equipment.

Occassionally, a senior officer is nominated as a focal officer for technical scrutiny of the lists of spare parts received from a number of projects when a Central Purchase Organisation acts on their behalf.

46.2. *Scaling.*

Scaling of requirements of spare parts for given items of machines involves the following steps:—

1. Scaling of provison (by value) for repairs of equipment in relation to service life of equipment;
2. Requirements based on physical inspection of equipment at the time of repairs;
3. Anticipated requirement of equipment for a defined period of time—generally equivalent to the lead time for procurement, but expressed in terms of equivalent numbers of operational hours; and
4. Going by an established scale of consumption of individual items based on record of annual consumption of repairs in the past.

In addition to such technical scaling of requirement, scaling for the procurement involves one more step. That relates to the stock position of the items included in the indent/requisition, as well as quantities that may be pending supplies against firm orders already placed.

A purchase organisation would generally have to set in getting the points as above attended, so that not only are the required spare parts made available in proper time and to the required extent, but that there are no large scale excesses of parts in stock or blocking of capital in consequence thereof.

4.6.2.1. *Initial provisioning for imported items.*

Generally speaking, the spare parts of imported origin to be initially purchased with new machines, cover two years' requirement of maintenance and operation. Further more, these supplies amount to 10% to 15% of the value of equipment; and these are necessarily indented along with the indent for procurement of the machine. The range of percentage value, as indicated, 10% to 15%, may get extended to the figure of 20% occasionally, if 3-shifts operation is envisaged for a given work. This again, is limited to certain specific categories of equipment, which are mostly engaged on heavy duty or have components which suffer heavy wear and tear by virtue of the particular type to which the machine belongs, e.g., a Crawler Tractor or a Motorised Scraper. Hence, it is the judicious discretion to be discretely used by the equipment owning authority in making a selection of the proper figure from the range from 10% to 20% by way of scale of requirement of spare parts to be initially procured with the new machines.

4.6.2.2. *Initial provisioning for indigenous items of parts.*

Similar consideration applies to the items of initial supply of spare parts of indigenous origin, except that the requirement may lie within the figure of 10% of the cost of machines.

Such requirements are generally limited to the operational and maintenance requirements over a period of one working season only.

4.6.2.3. *Subsequent provisioning.*

In order that availability of equipment is ensured for sustained operation of the machine in overall interest of optimum utilisation and maximum production, it is again essential to order out the spare parts of imported origin-- beyond the first two years' requirement as covered through the initial supply, within 3 months of the receipt of the machines, on the project; or if the spare parts catalogues etc., are available earlier, even simultaneously, with the receipt of the machines with the user. Such indents should cover the requirements of spare parts for first overhaul of the machines and its maintenance requirements in operation for a period of one following year. This is mainly with a view to ensuring timely availability of spare parts based on the assumption that the lead time in procurement of imported parts is 18 to 24 months.

In view of the fast growing indigenous manufacture of Earthmoving Equipment in the country, it becomes all the more necessary that for the items of equipment of imported origin available with various users, judicious planning in ordering the barest minimum quantities of parts should be made so that after the machines have outlived their economic span of life, at which stage these would be replaced by equipment of indigenous origin, huge stocks of spare parts should not be left with the user to lie in dead storage in absence of the machines which would be scrapped. Though this facet of the problem in relation to equipment of imported origin invites special attention, the envisaged control should have an extended application to ordering/import/purchase of the spare parts in relation to the equipment of indigenous origin also. Hence with the overall objective of barest minimum investment in purchase of spare parts for maintenance and repair of the construction equipment, it is highly essential that proper inventory control system be introduced at the earliest possible.

4.6.2.4. *Minimising critical indents.*

In spite of the best care taken to scale the requirements of spare parts with the main objective of reducing investments in stocks and avoiding idle storage of parts over long periods, it is inevitable that the equipment operatives would face shortage of some of the spare parts. Such requirements are listed as 'unforeseen'. Forward indenting of spare parts based on a scientific inventory control system and a properly established scale of consumption would, no doubt, substantially reduce the list of such critical items which get to be in short supply. It is a matter of general observation that about 5% to 10% of the required parts would not be available from ready stocks or from incoming consignments against pending orders. Emergency breakdowns may also create such unforeseen demands.

The possibility of such requirements of critical items can be minimised if indenting of requirements is done on forward planning based on half-yearly intervals of time.

4.6.3. *Inventory Control System.*

In the act of creating inventory, there are two fundamental questions, which must be answered in every instance, namely (1) How much to buy at one time; and (2) when to buy this quantity.

Answers to these two questions must come from a proper consideration and evaluation of a number of factors having a bearing on inventory and its control. Four of these factors are fundamental and, without consideration for costs could form the basis for decision on how much to buy, and when to buy. These are as follows:—

(1) Requirements, or demand, on a unit/ time basis. This is based upon information from proper records and forecasts schedules.

(2) Quantity in stock and on order. This again is obtained from a proper record, held with the stores organisation. The Ledger Record generally kept, shows stock balances, quantities on order, and the maximum consumption at any time, or even in given periods of time.

(3) Procurement time, or lead time—the total length of time taken to obtain a fresh supply of the item.

(4) Obsolescence. Consideration must always be given to the possibility of design changes, or other factors, which would make the particular items obsolete.

Attention is also to be given to reducing inventory costs and accordingly, the following considerations must also be added to the above list:—

(i) The ordering costs—the expenditure on processing of purchase orders or the establishment that handles the work of procurement of the items required.

(ii) Inventory carrying costs, or inventory holding costs. This factor includes interest rate on average amount of capital invested in stock, insurance charges, if the goods are insured in the warehouses, cost of depreciation and obsolescence, and cost of storage facilities (that of premises or depreciation of buildings, cost of lighting arrangements, air conditioning arangements etc., in case these are involved for proper storage of some of the items etc.) mainly related to the floor space of the storage area in relation to the particular items under consideration, and handling costs.

While it is not intended to enlarge upon the details of this subject too elaborately in this report, it is considered necessary to touch upon the basic details of the Inventory Control system in relation to the spare parts for earthmoving machines and other construction equipment.

4.6.3.1. *Categories of requirement of Spare Parts.*

The spare parts required for any project, or a number of projects could be divided into the following broad categories:

(a) Regular fast moving spare parts

(b) Slow moving parts

(c) Emergency or protective parts.

Regular Fast Moving Spare Parts

All items whose replacement frequency is fast and the consumption and usage can be predicted would fall in this category. The consumption would be proportional to the service time of the machine (hours or miles' run) the number of units in operation, the operating conditions and other factors such as operaation efficiency and planned maintenance. For earthmoving equipment items such as track parts, filter elements, brake parts, clutch plates, bushes, hoses, bearings, and other moving and rotating parts, would fall under this category. It would be necessary to stock these parts in sufficient quantities so as to maximise equipment utilisation. The storage of such parts at project site is better, but central storage would also be necessary.

Slow Moving Parts:

These are those parts which may have some pattern of movement, but the frequency of interval is fairly wide. Such parts may have a movement of one or two in an year, and in some cases, may have movement over alternative years. Such infrequent replacement of parts is usually at the time of overhauls or in emergencies. These should be considered for stocking at project site taking into account the number of similar machines in operation. The replacement of such parts should be done by the central inventory control. Parts in this category would be items like radiators, radiator cores, cylinder heads, crankshafts, turbo-chargers, clutch drums, hubs etc. Slow moving parts should be considered for interproject transfers, and it would be essential to keep an account of the stocks at various locations in the central inventory control unit.

Emergency or Protective Stocks:

Items under this category should only be kept in central inventory control. These stock items would consist mostly of assemblies or sub-assemblies of machines which are not normally required, but are required in emergencies, where the absence of these would cost prolonged shut down of the machine, and result in serious loss of production. These items normally do not have any pattern of movement, and/or they will have extremely slow movement, and it is virtually impossible to predict when they will be required. Typically, an item in this category may not be required for 3/4 years, but a sudden requirement of 2 numbers may crop up in one location, or in two separate positions. This would be classified as a purely random occurrence. Investment of funds in such parts is purely a "risk" decision so as to overcome costly losses due to down time. Items in this category would be gear box assemblies, spare engines, differentials, generators, motors, etc.

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4.6.3.2. *Record keeping.*

The backbone of a good inventory control system is proper records. The following functions are absolutely necessary in all inventory systems and must be installed at the outset.

(a) Historical record of machine demands.

(b) Maintaining a perpetual record of quantities of each item in stock and on order.

(c) Determination and implementation of realistic inventory levels.

(d) Use of properly trained personnel.

The data processing can be with the use of either the conventional visadex/Kardex system, or by punched card machines. Specimen cards and forms are given at appendix 4.3.

4.6.3.3. *Choice of spares.*

If the machine is new, the spare parts selected for stocking would generally be on the basis of suppliers' recommendations. They normally indicate which of the spare parts are fast moving and should be stocked based on their wide and general experience. The details should, however, be subjected to scrutiny at competent level to avoid overstocking of redundant parts.

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Once historical data accumulates, then it is easy to select the fast moving spares that are needed by means of consumption analysis. This would give a realistic pattern based on actual conditions prevalent in the system.

4.6.3.4. *A.B.C. Analysis (high, medium & low value Analysis)*

The firm basis of all inventory control systems is the ABC analysis by consumption. ABC Analysis enables the inventory control man to select the costliest items in the inventory and thus by concentrating attention on 'A' category items, he controls maximum inventory with least effort. It also provides information on movement of items for classifying into slow and fast categories.

The first step in making ABC Analysis for *consumption* is as follows:—

Step I

Item Serial Number	Part Number	Unit price.	Consumption during a year total units	Consumption value
		Rs		Rs.
XXX	XXX	11.00	100	1.100

The second step is to arrange the items in descending order of consumption value:

Step II

Item Serial Number	Part Number	Consumption value (Rs/Year)	Cumulative consumption
1	XXX	10,253	10,253
2	XXX	9,250	19,503
3	..	..	..
4	..	..	..

Step III

Draw a graph with number of items on X-axis, and cumulative consumption value in Y-axis.

It will normally be found that the following holds good:

Items	Value	Category
10%	70%	A
20%	20%	B
70%	10%	C

The first ten percent of items costing 70% are called 'A' category items, next 20% items costing 20% of value 'B' category items and the lowest consumption 70% of items costing 10% of value are called 'C' category items.

The secret of good inventory control is to concentrate attention on 'A' and 'B' category items, which are only 30% in number, but account for 90% in value of consumption or turnover.

If proper care is taken to see that wherever figure of value is Rs. 1000 or over in respect of individual items on unit price basis or for the total quantity against an item, the items could be examined for verifying if basically the item is required at all or if the quantity being ordered is reasonable, keeping in mind the consumption of that particular item over the past 2 or 3 years and the quantity ordered/in stock, in respect of the items. This would help in framing the requirements of costly items of spare parts on realistic basis and consequently this would help in keeping down the value stocks of spare parts at the users' end.

4.6.3.5. *Maximum and minimum stock limits and quantity on order.*

While sophisticated systems based on Economic order Quantity and other economic criteria can be designed for specific situation, a simple inventory control system based on a general criteria is being outlined below. Such a system is considered adequate till more statistical data is gathered (in 2/3 years).

Let L=Lead time in months (the time between the placement of indent for the item and receipt in the stores concerned.

$\overline{X}$=Average quantity consumed per month in numbers

$\overline{R}$=R.O.L.=Re-order level (the number of units in stock and on order when a fresh indent for the item is to be placed).

$\overline{M}$=Maximum stock at any time.

$\overline{O}$=Quantity for order

Total available=Quantity in stock + Quantity on order.

The following levels are recommended, taking for granted that all quantities shown are total available and not physical quantities.........

Category	Maximum	ROL or minimum	Order Qty
A	$\overline{X}$ (L+4)	$\overline{X}$ (L+1)	3$\overline{X}$
B	$\overline{X}$ (L+2)	$\overline{X}$ (L+2)	6$\overline{X}$
C	$\overline{X}$ (L+15)	$\overline{X}$ (L+3)	12 $\overline{X}$

The rules are:—

(a) Defer/Cancel orders when maximum is reached.

(b) Place fresh indents when minimum is reached.

(c) Order quantity is equal to (Maximum-Minimum).

It may so happen that in many cases the quantity could be a fraction. The general rule would be to round off to the nearest integer. However, if maximum and minimum become the same quantity a difference of 1 is kept for orderly working of the system.

For slow moving spare parts, one or two complete sets are kept on the basis of earlier consumption and number of points of use.

4.6.3.6. *Centralised inventory control (CIC).*

The centralised inventory control should hold in its stock all slow, protective or emergency spares. No hard and fast rules can be given for the items to be kept in CIC. 'A1' can be defined tective spares to be kept in C.I.C. should have atleast 3 to 4 machines working at different sites or projects. In addition, stocks of fast moving parts common to all projects must be kept in the Central Inventory Control.

One way of tackling the problems would be to carry A B C Analysis of stocks for value held in various projects as on a particular date. The 'A1' category items by stock value will be the items to be kept in CIC. 'A1' can be defined as the first 5% costliest parts (unit costwise) and can be taken for Indian conditions as assemblies and sub-assemblies costing more than Rs. 3,000 per item. However, the exact value has to be determined by the individual CIC Cell depending upon the type of machines in use and the value of the costliest parts required for those machines.

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It is important to note that only spares for machines which are common to two or more projects are to be kept with CIC. When these parts are required for replacement on machines, they are to be transferred to the concerned project quickly.

The decision rules are typical when not more than 5 machines are available at the same time.

Maximum	Minimum	Order
1	0	1

For 10 machines

Maximum	Minimum	Order
2	1	1 etc.

4.6.3.7. *Cardex cards for CIC*

The specimen Cardex Cards in which CIC information is to be furnished is given at Appendix 4.4 which is self explanatory. Consistent with the procedure in vogue, the individual indentors are supposed to check up the quantity in stock/on order in respect of each item included in the lists of goods. However, it is not clearly known if such a check is being actually exercised by the indentors at the time the indents for purchases are made by them. If cardex system is maintained properly, ready reckoning could be done in respect of quantity on order/in stock in respect of each item, as also the level of consumption of the individual items over a given time. Basically, therefore, introduction of a Cardex system or any other substitute system to achieve the same objective, has to be properly done at this stage.

There is evidence of impression in some quarters that maintenance of a Cardex system is more expensive, compared to the conventional system of Bin Cards and ledgers. In order to illustrate what may be the cost to mantain a Cardex system, so that there may be no wrong notions about the cost of maintenance of such a system, details have been given in the following paragraph to project the probable operational costs.

The operational cost involved in running the cardex system which may necessitate empolyment of 5 store-keepers with a monthly pay of Rs. 300 each, 2 Supervisors, expert in cardex system, with a monthly pay of Rs. 800 (annual expenditure amounting to Rs. 37,000 to 40,000) for inventory of 50,000 items valuing at Rs. 70 lakhs to Rs. 80 lakhs. The amount of expenditure is justifiable, as this would mean $\frac{1}{2}\%$ expenditure in relation to the cost of the spare parts (leaving aside the capital cost of cardex system). Even if $\frac{1}{4}$th of the total value—say Rs. 20 lakhs is removed from dead storage and all the idle capital otherwise involved is made more productive by curtailment of such items or by reduction in the inventories, the expenditure of Rs. 40,000 a year would be amply justified.

4.6.3.8. *Conclusion.*

The basic elements which enter into consideration for introducing the Inventory Control System are not too complicated in nature. However, what is necessary is the basic training in this field in the Inventory Control and it may be a useful proposition to get some senior officers trained for this purpose.

With the exception of one of the River Valley Projects, namely, Ukai Dam Project, the Inventory Control System has not been effectively introduced on any other project. Amongst users of such equipment in Public Sector Undertakings, the NMDC are the only other example to quote for establishing properly organised Inventory Control System. Hence, the experience in this regard in the country is rather limited, though the subject by itself is highly important, if the costs of inventory of spare parts have to be reduced both in terms of stock values and in terms of inventory carrying costs.

4.6.3.9. *Nonstandardisation makes inventory control difficult.*

The reason for most of the users of equipment not resorting to Inventory Control System in the matter of procurement of spare parts etc., is that the standardisation aspect could not be achieved to the required/desired extent. Each major user of equipment is faced with the problem of having to buy the equipment based on cheapest price (because the equipment has been of imported origin so far and the financial stipulations for such purchases have been governed more by the concept of "Cheapest buy" in monetary terms rather than the "life-time-concept" of the price of the equipment to be purchased). The huge assortment of makes and categories of equipment amassed on each major operation, makes it difficult and cumbersome for the inventory Control System to be effectively executed at most of the River Valley Projects, a minimum of 6 to 8 makes of equipment are in use, if not more. There are cases to quote where even 15 to 20 makes of equipment have been put to use. In the matter of Power Units Diesel Engines installed on these machines, however, standardisation has been achieved to some extent. But even in this respect, a minimum of 4 to 5 makes of Diesel Engines are in use on different items of equipment.

4.6.4. *Purchase Manual.*

Whereas according to the present methods and systems, the steps as indicated in para 4.4.5. are being followed, it may be necessary to indicate that a unified procedure is not seemingly being followed with a view to eliminating possibilities of delay in the process of procurement of stores. For instance, the framing of requisitions and indents, notices inviting tenders, evaluation of tenders and providing proper terms and conditions for supply of the goods against finalised purchase orders, do invole deficiencies of some kind where the ultimate placement of orders gets delayed. It is of utmost importance that the format of all documents for processing the requisition of spare parts to the point of placement of purchase orders for supply of spare parts, should be clearly defined with all necessary technical and commercial points covered therein, in terms of precise writing. Only then will it be possible to reduce the time taken to finalise purchases to the minimum possible. The procedure, system and method of procurement are integrated into a volume called the "Purchase Manual". The Purchase Manual lays down clearly the set of rules to be followed in processing the requisitions or purchase requests to the point of physical delivery of the items to be purchased into the Stores. The Manual also includes the set of proformae to be followed for reporting statistical information in relation to procurement/purchase of parts as well as the value account of inventory and the elements of costs which get involved for finally determining the "issue rates' of the spare parts for their use on the machines.

The Purchase Manual is the main 'guide book' providing rules of procedure, methods and systems of purchase not only in respect of the items of spare parts for equipment, but also for purchase of any other stock items of materials etc., required for the particular works where the equipment is also employed on the job.

It is customary for any major project—be it related to construction work, mining, road-building, land reclamation etc., to have a separate set of rules to govern the procedure of purchases. While there may be some functional differences in the set of rules--specially those related to powers delegated to the officers in charge of the project, or those associated with the work on different jobs or projects, basically the method and system of procurement of purchase would be more or less, the same. In most cases, the terms and conditions which form a part of the Purchase Orders in their final form, are almost identical except the mode of payment, or terms of payment, which vary to some extent, depending upon the local conditions on a project, its geographical location and the mode of transport of goods to be supplied. Hence the nature of variables is limited to the evaluation of certain factors in monetary terms while the fundamental elements remain the same.

In evolving the Manual of Purchase in any Government Department, a Public Sector Undertaking, or on a Project, the main guidance is generally taken from the Manual of Purchases developed by the DGS & D.

The forms of reporting, however, vary a lot from one work to another, consistent with the functional aspects of the commodities to be purchased. These are devised and finalised by the individual project authorities/purchase Organisations, to suit the convenience of the accounting system in use.

4.7 Surplus Stock

4.7.1. *Dead Stock and Obsolete Stock.*

It is the observation of the Committee that substantial stocks of spare parts reman unutilised and undisposed even long after the completion of the work on which the equipment was employed. This would refer mainly to the work done in the River Valley Projects, where a time bound programme is followed and not the production jobs as in the Mining Sector. From the statistics complied, it is seen that spare parts worth about 10% of the value of equipment were left as surplus on completion of the project work. It took about 6 to 8 years to dispose of or rehabilitate about 50 to 60% of the residual stocks, while the remaining 40 to 50% stocks were left as 'dead stock'. In due course of time, the spare parts which belonged to certain makes and models of machines, proved to be obsolete due to equipment of more recent origin having been in use on other projects, while the old equipment had completely outlived its useful life, either on the project where the stocks are held, or on other projects where the equipment was subsequently transfered. Thus, about 5% of the total stocks of spare parts (in terms of value of the total receipts on the project considering life time) were left out as "dead stock items".

4.7.2. *Losses on Stock.*

Since the inventory carrying costs also make an important item of costs, in overall operation of equipment, it is necessary to consider a point or two in relation to this. Besides the amount of capital investment made in the stocks of spare parts, the interest charges that would be accruing year after year, on the capital cost so invested, as well as the expense that would accrue by way of storage space provided to hold the stock, the main factor to be considered is that of losses on stock due to physical deterioration or shrinkage or the obsolescence costs.

In accordance with an analysis made by the NMDC, the inventory holding costs amount to 15 to 20% of the value of the spare parts held. This would reflect the magnitude of the annual recurring costs on holding such inventories without turnover.

4.7.3. *Transfer of Dead Stock.*

There are cases to quote where, on completion of work on a project, the whole lot of spare parts available for a particular machine were transferred with the machine to the transferee project. These stocks of spare parts continued to be held at the transferee project warehouse without much turnover or usage. The inventory holding costs were being incurred while holding such items in "dead stock".

It therefore, becomes necessary that the projects should not transfer such stocks of spare parts with the machines, except to the extent of transferring such portion of the stocks as could be readily utilised by the transferee project. The balance stocks should be disposed of to be best adavantage of the project.

4.7.4. *Associating dealers for disposing of the surplus stock.*

The Committee have also considered the possibility of assistance being afforded by the accredited agents of equipment in the country in disposing of such items of surplus spare parts etc. Such dealers of equipment keep importing spare parts against new requisitions/indents received by them from various users of equipment in the country. Most of these items of spare parts being of imported origin, valuable foreign exchange is expended in making fresh imports of the items while some of the required items would still be available as surplus with the projects. If the dealers of equipment are furnished with lists of surplus spare parts by every user of equipment in the Government or Public Sector, they can always apportion the available items of spare parts to the new requisitions or indents received by them for import of spare parts and divert such items to the prospective indentors thus saving the valuable foreign exchange that would be involved in fresh imports of the items. The dealers could be paid certain service charges for such co-ordination.

The sale value or such items could be related to the present day market price as the prospective purchaser has even otherwise to incur that expenditure through new purchases from abroad. In this process, the dealers' service charges could be properly met with by the stock holders and the balance amount would not be upset seriously to invite any serious audit objection from financial angle. A part of such premium of price could also off-set the losses incurred due to shrinkage or losses or due to expenditure by way of inventory holding costs of the surplus spare parts. It would not be a matter of making a profit, but only to make adjustments for the losses and other costs normally involved in holding such stocks of spare parts.

4.7.5. *Central Cell for Surplus Disposal.*

The Committe also feels that a Central Cell may be created for the purpose of surplus disposal, who would keep the records of all surplus stock and arrange to dispose them of through transfer or sale. A Study Group has to be created in the first instance to go into the details to lay down the organisation and functions of the Cell.

4.8. **Summary of observations and Recommendations.**

Even though every major user of equipment has a fairly well organised establishment for procurement/purchase of spare parts, there is evidence of lack of control in the size of the inventory of spare parts. Basic assessment of requirement of spare parts is generally done by junior officers, who do not have a clear knowledge of the history of performance of the machines—types of breakdowns during the period of operation, their frequency, the details of repairs carried out and the parts consumed etc., etc. Neither do these officers have an understanding of the future requirements by way of identification of parts which would be required for future repairs.

Some times for imported equipment which is likely to be replaced by indigenous equipment in the near future, spare parts are procured in abundance.

The situation would improve if senior officers, having a background of experience in working with equipment, their repairs and maintenance, are assigned the work of preparing lists of requirements of spare parts. They should be further guided by statistical data compiled by a well organised Inventory Control Cell who should develop a clear pattern about the consumption of individual items of spare parts in different classifications, valuewise.

The purchase organisations face handicap in procurement of imported items borne on DGS & D Rate Contracts. This results from the restrictions and limitations in the value of identified restricted items, that can be imported, the limited value of licence given to the Rate Contract holders at longer intervals of time, etc. Nonavailability of Rate lists in respect of items included in supply orders, not only at the stage of placing the supply order, but occasionally even when the consignee invoices are received, make it difficut for the purchase organisation to size up the value of the purchase.

In relation to Rate Contracts for indigenous spare parts, quality of parts is often not upto the required standard, or in some cases, supplies are either not made or inordinately delayed.

Whereas perpetual review of inventory of spare parts is one of the most important functions of any stock-holding organisation, this is not done in practice. For various reasons—partly attributed to lack of inventory control and partly to basic assessment of requirement being erroneous, the spare parts stocks have been mounting high with individual users of equipment. If perpetual review of inventory is carried out, the surplus items or excessive stocks could be suitably disposed of, causing reduction in investments and simultaneously making them available for gainful use by the needly users elsewhere.

Processing requisitions of parts for procurement at longer intervals of time—one year or longer, results in bigger lists of critical items of spare parts which are to be procured emergently—sometimes these take the shape of panic purchases. To regulate this process, half-yearly indents would be a better proposition. The statutory limit imposed by the Import Trade Control policy in the import of emergency spare parts at 0.1% of the capital cost of equipment, also necessitates indenting of parts in this manner. All the same, in order that the emergency requirements are suitably met to the extent these essentially arise on work with earthmoving machines, etc., the limit for emergency imports has to be increased to 1% of the capital cost of equipment each year. It is also important that these licences should be issued most expeditiously.

In conclusion, it can be stated that if the established methods, systems and procedures of purchase have to effective, the following steps would have to be taken:—

1. Each major user of equipment should establish a scientific inventory control system.

2. The scaling of requirements of spare parts and preparation of indents for procurement of same should be done by senior experienced officer, who have the required knowledge of equipment and their performance characteristics.

3. In order to reduce the size of inventory of spare parts in a sector, in a State collectively for various small sized projects, Central Purchase Organisations should be set up for processing the requisitions for procurement of parts. They should be assisted by Inventory Control Cells for proper assessment of the level of stocking of the parts with the due consideration to the consumption pattern, the period of time for which the spare parts planning is done, the lead time of procurement etc.

4. Perpetual review of inventory should be organised. Disposal of surplus spare parts identified as a result of such review, should be undertaken by a Central Cell in a State or in a Sector.

5. The DGS & D may examine the reasons why the Rate Contract holders cannot, stick to the delivery schedules, furnish price-lists of goods ordered against rate contracts and expedite finalisation of rate contracts. In respect of rate contracts for indigenous items, a more meticulous check may be exercised in identifying the established facilities, technical know-how on part of the manufacturing concerns, the research and development and design set up available with them and the goods being actually manufactured by them at the time the new items of spare parts are planned for manufacture by them. The quality control aspect will be better covered by this process.

6. Every major Project/State should prepare Purchase Manuals incorporating therein, the rules, procedures and systems of procurement which will serve as guide for materials management.

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CHAPTER 5

REQUIREMENT OF EQUIPMENT DURING THE 4TH FIVE YEAR PLAN, IMPORT SUBSTITUTION AND STANDARDISATION

5.1. **Requirement during the 4th Plan**

5.1.1 *The Basis of Assessment*

The exercise on assessment of requirement of equipment would basically involve consideration of, (i) adequacy or inadequacy of the available equipment for the works/schemes under execution, (ii) additional requirement of equipment by way of replacement of old equipment on the continuing schemes, and (iii) additions to be made for augmenting the new schemes identified for development in various sectors.

5.1.2.1 *Adequacy or inadequacy of available equipment*

The adequacy or otherwise, of the available equipment, in relation to the targetted programmes of work in different fields, where such equipment is employed, is a direct result of the basic planning initially done in providing the equipment for particular activities.

In the past, there have been some short comings in the basic exercise of plant planning in as much as most of the users of equipment in the country, who are located in Government Sector or Public Sector Undertakings, have been guided in their assessment of requirement of equipment by the norms of production by individual items of equipment as fixed by the manufacturers of equipment abroad, or in some cases, by the guidelines set forth in terms of production achieved by some of the users of similar equipment in the country. In both these cases, however, proper consideration has not been given to the exact conditions and situations in which that equipment was employed, and the likely improvements that could be made in overall management and control of the equipment, so that better production is achieved with the available equipment by ensuring optimum utilisation thereof. This conclusion is based on the fact that certain time-bound programmes have been executed with the help of equipment so selected, quantitatively, based on the guidelines and norms previously established or recommended, while the overall utilisation of equipment has been much below the expected standards. The average utilisation of equipment in the country is around 40 to 50%. Of course, this consideration cannot be isolated from the problems faced by an average user of equipment in getting the required maintenance supplies by way of spare parts etc. These problems are of great consequence when related to the policy and rules governing import of spare parts, which is a matter beyond the control of the equipment owner.

Hence, it is rather difficult to give a concerted opinion on the adequacy or inadequacy of the available equipment in relation to particular jobs, where these are employed.

All the same, it is gratifying to note that an average owner of equipment in the Government/Public Sector is now well seized of the aspect of engineering economy and equipment economics, in order to make the cost of the end product produced by these machines cheaper even with the rising costs of equipment, labour and materials. A good deal of attention is now being paid to the operations research, and time-and-methods-studies in fields where intensive use of such equipment is made.

5.1.1.2 *Replacement*

In so far as replacement of equipment and additional requirement thereof in consequence of such replacement is concerned, this arises only in such areas of work where continuous use of such equipment is made on jobs, which have to last for fairly long periods of time—in some cases even 30 to 40 years. The production of coal, Lignite, Iron Ore, minerals and metals etc., are the fields where such is the case. On construction works—building of

Dams, Canals, Roads etc., the equipment does not spend its entire useful span of life on the job. On completion of such works, the residual value of equipment is generally known to be 30 to 40% of its initial acquisition cost—though in exceptional cases, the residual value is as high as 50 to 60%. Only in exceptional cases, where large volumes of work have to be done with machines on multipurpose projects, like the Beas Dam Project, the Nagarjunasagar Dam Project, the Hirakud Dam Project etc., etc., that additional requirement of equipment arises at certain stages during the construction period, in terms of replacement of the old equipment. Most of the times therefore, certain amount of surplus equipment is left behind on completed projects and such equipment can be utilised profitably on other continuing or new schemes.

There is, however, a general tendency on part of the project authorities handling new schemes, not to take the old, used, surplus equipment from completed projects, except for certain minor items of works, unless the scheme as a whole is of a very small magnitude warranting use of equipment for every short period of one or two years. The status so obtaining is manifest from the difficulty experienced by most of the completed projects in rehabilitation/disposal of surplus equipment. Sometimes, even for the medium schemes in the Irrigation and Power Sector, such old equipment is rehabilitated on the job with some hesitation.

5.1.1.3 *Additional requirement for new schemes*

In so far as the additional requirement for the new schemes is concerned, the reckoning in this behalf starts from the basic plant planning exercise. Integration of various factors like phased programme of work time-wise, the quantities of individual items of works to be executed in given periods of time, the financial estimates of work to be done, the facilities available for maintenance and operation of the machines including repairs, has to be properly done. Unfortunately, the basic formulation of the schemes at the stage of preparation of project estimates, is void of detailed analysis of the annual programmes of work while the estimate of requirements of equipment is included in the project estimates are still indicative of the types and quantities of equipment that may be purchased. It is only after the work on a new scheme has commenced, that the exercise of plant planning is made afresh and is continued to be done over a fairly large span of time. Procurement of equipment is further controlled by the financial resources available for investments unto cost of equipment from time to time. Hence, this remains an indeterminate factor due to such conditions of suspense. No doubt, an attempt is always made to foresee the total requirements of equipment well in advance, but in effect the constraints on financial resources defeat the purpose of precision in making proper and final assessment of requirements of equipment.

Sometimes, lack of adequate data regarding availability of materials to be handled by the equipment also makes the assumption of requirement of equipment rather indeterminate.

Yet another factor which makes the assessment of requirement of equipment for a particular project rather indeterminate is the possibility of work on the project being awarded to contractual agencies. Whenever a portion of the work is allotted to a contractor, the contractor employs his own equipment on the job and therefore, the project authorities do not make investments in this regard. The extent upto which apportioning of work to the contractors and the departmental agencies is finally done, cannot be conveniently determined in advance. More often, such decisions are taken based on availability of the resources at the command of the project authorities—equipment, man-power, materials etc. Hence, this factor also handicaps the assessment of requirement with precision.

Hence, in relation to a given period of time—like a Five Year Plan period, the project authorities cannot always phase the programme of procurement of equipment with precision. At best some forecasts of such requirements can only be made.

5.1.1.4 *Integrated exercise—a colossal effort*

Hence, if an integrated exercise is to be carried out in making an assessment of the requirement of equipment for the future, various aspects as defined above have to be taken into consideration. However, for this to be made feasible, a more elaborate exercise is to be done, which the Committee have found it difficult to do in view of the colossal effort that may be involved. Accordingly, the Construction Plant and Machinery Committee have collected statistical information relating to equipment available in the country with most of the users and the component thereof surplus with them.

5.1.2 *Appraisal of Available Equipment*

5.1.2.1 *Census of equipment*

The total value of equipment available in the country is estimated at Rs. 3,500 million, and 20,000 in number. Approximately 6.6% of the available equipment (by value) and 12.5% by numbers, is shown as 'Surplus'. Further more, 66% by numbers and 75% by value, reflect the quantum of equipment in working condition in relation to the total available equipment.

5.1.2.2 *Major users*

The major sectors using such equipment are the following:—

1. Irrigation and Power Sector.
2. Mining Sector (including N.M.D.C., N.C.D.C., Neyveli Lignite Corporation, Hindustan Steel Ltd., Mineral and Metals Department, Cement Industry).
3. Rehabilitation Reclamation Organisation.
4. Directorate-General of Border Roads.
5. Agriculture.

In a large number of cases, in the areas relating to the above defined sectors, private agencies own fairly large fleets of equipment for doing similar/identical work with equipment.

The statement prepared by the Committee, showing distribution of equipment in different sectors, is at Appendix 1.1. In this case, however, grouping of equipment has been done on a slightly different consideration by identifying the sectors as follows:—

- I. State Government Departments (including Irrigation and Power Sector).*
- II. Central Government Departments.*
- III. Government bodies/Corporations/Public Sector Undertakings.
- IV. Private Bodies.

5.1.2.3 *Broad categories of equipment*

The broad categories of items of construction plant and equipment in use in the country, are as follows:—

1. Exploratory equipment.
2. Power generation equipment.
3. Earthmoving equipment.
4. Tunnelling equipment.
5. Quarrying equipment.
6. Crushing, screening & processing plants.
7. Concreting equipment.
8. Road building equipment.
9. Transport and material-handling equipment.
10. Compressed air equipment.
11. Misc. equipment.

On sampling the information relating to census of equipment available in the country, it is observed that 80% of the value of equipment in use is covered by one category, viz., earthmoving equipment, which is compressed of the following items:—

1. Excavators—shovels and draglines, cranes, bucketwheel excavators etc.
2. Crawler tractors and front-and shovels mounted on crawler tractors.
3. Off-the-highway-dumpers.
4. Motorised scrapers.
5. Graders.
6. Wheeled Tractors and loaders.

The remaining 20% items of equipment are comprised of assorted items under different categories mentioned above.

Hence, for purposes of assessment of requirements of equipment and relating this to the established indigenous capacity from standpoint of import substitution, the study made by the Committee is mainly related to these main items of equipment.

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*The value of equipment with the Irrigation and Power Sector is Rs. 1,350 millions, as shown in Appendix 1·7. The balance amount of value in Appendices 1.3 and 1.4 would represent the value of equipment with other Departments under the State Governments/ Central Government.

5.1.3 *Assessment made by the Working Group for Construction Equipment in* 1968

The Working Group for Construction Equipment constituted by the Ministry of Industrial Development and Company Affairs in 1968, had made an assessment in respect of annual requirements of certain selected items of equipment during the 4th Plan period. The items and the quantitative requirement against each as indicated in the report of the Working Group are as follows:—

	Item	Nos.
1.	Excavators 3/4 cu. yds.	25
	1½ to 4½ cu. yds.	115
	6 cu. yds.	14
2.	Crawler tractors 120-150-200 h. p.	200
	225-300 h. p.	125
	300 h. p. and above	30
3.	Dumpers: 5-6-T capacity	75
	15-16-T capacity	200
	20-25-T capacity	200
	35-T and above	100
4.	Motorised Scrapers 7/12 cu. yds. to 24/30 cu. yds.	75
5.	Motor Graders	50
6.	Front-end Loaders (on Crawler Tractors)	125
	Front-end loaders (Wheeled)	50
7.	Mobile cranes 10-T to 45-T capacity	75

In terms of sale value of these items, the estimated annual requirement were assessed at Rs. 780 million.

It was also estimated that the export potential would be of the order of 10% of total production. Hence, the value of the balance equipment expected to be sold in the country was of the order of Rs. 700 million a year.

Assessment of requirement for the remaining period.

In view of the emphasis laid on completion of the work on continuing schemes on Irrigation and Power Projects during the 4th Plan period, better utilisation of the installed capacity of plant and equipment in various other industries and the curb on imports, the additional demands or requirements of equipment were not largely generated during the first three years of the 4th Five Year Plan. As of the present, however, with the concurrent mid-term appraisal of the 4th Five Year Plan and projection of the envisaged development activities during the 5th Five Year Plan, a different picture of the future pattern of requirement of construction plant and equipment is getting developed gradually. In so far as the remaining two years of the Plan are concerned some new schemes have been approved and the Departments/Sectors councerned have initiated action to create additional resources by way of equipment, materials etc. to boost up the programmes of work in this period. This sudden spurt has caused a slight imbalance between the availability of equipment and the requirement: and as a result thereof imports of equipment have become necessary even in categories which are currently being manufactured in the country. Such imports largely relate to the work being done in the Iron-ore Mining Sector, Coal Mining Sector and the Irrigation and Power Sector.

The requirement of additional equipment in these Sectors during the remaining two years of the 4th Plan, as indicated by some of the Major users, is as follows:—

	Sector	
1.	Irrigation & Power Sector	400 M
2.	Iron-ore Mining Sector under N.M.D.C.	155 M
3.	Coal Mining Sector under N.C.D.C.	150 M

In view of the large number of indeterminate factors which influence the formulation of estimates of work and resources the individual Sectors who are the main users of such equipment have not been able to make a precise assessment with regard to items of equipment and the quantities against each that they would like to add to the existing fleet during the remaining period of the 4th Plan. All the same, if the value of equipment purchased in the past by such users in the country is to be an index of the future demands, the following figures may provide an interesting study in this respect:—

Year	No. of machines purchased during the year	Purchase value thereof (Rupees Million)
1969	940	330
1968	917	240
1967	1066	320
1966	1331	250
1965	220	390
	Total Rs.	1530 million

Thus, at an average, the annual purchases of equipment during the 5-year period 1965-69 amounted to Rs. 300 million approximately. Almost 75% of this equipment was of imported origin, while the remaining 25%, of indigenous origin.

The information collected by the Committee also indicates that during the year 1970 additional equipment worth Rs. 210 million approximately was purchased by them. The comparatively low figure of these additions in the year 1970 further substantiates the consideration that the work on continuing schemes has to be pushed up while the development programmes of the future were yet to be more precisely decided upon.

Considering the value in terms of the present day market prices, in respect of indigenous equipment there has been an increase of 25% above 1968 prices. In respect of the imported equipment also, there is about 20% increase, while the cost of indigenously manufactured items is about 25% above the comparable counter number of imported equipment. Hence, in terms of present day value, the cost of equipment corresponding to Rs. 300 million per year in the past, would be Rs. 400 million approximately. With an ambitious programme of development of industry in major sectors—Iron Ore Mines, Coal, Minerals and Metals, Cement and Irrigation and Power, when the Plan outlay figures are expected to be twice as much as for the 4th Plan period, it can be anticipated that the requirement of equipment will substantially increase and before the end of the 4th Plan, it may touch the Rs. 500 million mark. This of course, would be subject to the availability of funds.

5.2 Tentative Assessment of Requirement Equipment of during 5th Plan Period

The Committee have also attempted to make an exercise for assessment of future requirements of equipment of the Major Sectors during the 5th Plan period. Even though the particular Sectors of industry are not precisely aware of the outlay figures, they have furnished the Committee with a broad outline of the estimated requirements of equipment based on their assessment in relation to some of the schemes which have to be undertaken from now on or mainly in the 5th Plan period. A brief summary of the requirements as intimated by them is in Appendix 5.1.

The total of these estimated requirements, sector-wise, is as follows:—

	(Rs. Million)	
1. Irrigation and Power Sector .	1400	
2. Govt. Undertaking/Corporations	800	
3. Other Govt. Deptts. in Union Territories	40	
4. Other Private Bodies . .	40	
Rs.	2280	million

This would amount to an average requirement of equipment at Rs. 450 million per year during the 5th Plan period.

If, as envisaged, the outlay for the 5th Plan for Irrigation and Power Sector and in other important industrial sectors, where intensive use of such equipment is made, is double of what it was during the 4th Plan period, it may not be wrong to assume that the requirement of equipment, during the 5th Plan period may come up to Rs. 550 million per year.

Keeping in mind the export potential, the annual requirements may be estimated at Rs. 600 million. A more precise assessment of the requirement of equipment during the 5th Plan period will of course be possible when the working group for construction equipment is constituted in the near future by the Ministry of Industrial Development and/or the Planning Commission.

5.3 Import Substitution

5.3.1. *Indigenous Equipment Available in the Country*

In making an appraisal of the equipment available in the country, the Committee have also examined, as to how much of the available equipment is of indigenous origin. From the information made available by the users of equipment, it is observed that 25% of the total population of equipment in the country is of indigenous origin. The main items of equipment which are of indigenous origin are the following:—

1. Excavators—6 cu. yd. capacity.
2. Excavators 1½ to 3 cu. yd capacity.
3. Motorised Scrapers, 14 to 18 cu. yd. capacity.

4. Dumpers, 12-T payload capacity to 50-T payload capacity.
5. Motor Graders, 130 h.p.
6. Crawler Tractors 95 h.p. to 250 h.p.
7. Front-end Loaders, Wheeled and Wheeled Tractor-Dozers, 2 cu. yd. capacity/100 h.p. capacity.
8. Air Compressors upto 1000 cfm capacity.
9. Concrete Mixtures 1 cu. yd. capacity.
10. Drilling Equipment of various sizes.

5.3.2. *Programme of Manufacture*

Even though the indigenous manufacture of items of construction equipment—specially earthmoving machines, started in early sixties, the manufacturers have geared up for production substantially from 1965 onwards. Bulk manufacture of a few items of earthmoving machines has commenced only recently—during the last 3 to 4 years.

On discussions with the Directorate General of Technical Development, the programme of manufacture of items of earthmoving machines during the years 1972-73 and 1973-74 is known to be programmed as follows:—

	1972—73	1973—74
	Nos.	Nos.
I. M/s. Bharat Earth Movers Ltd.		
1. *Crawler Tractors*		
D— 50	300	300
D— 80 . . .	200	200
D—120A-18 . . .	120	120
2. Motor Grader . .	35	35
3. Motorised Scrapers .	40	40
4. Haulpak Dumpers . .		
(a) LW-25 . . .	50	50
(b) LW-35 . . .	150	150
(c) LW-50 . . .	20	20
5. Front-end Loader TIGAR	50	50
	965	965
II. M/s. Hindustan Motors Ltd.		
1. *Terex Equipment*		
(a) Dumpers 25-T payload Capacity . .	100	100
(b) Crawler Tractor Model 82-40 . .	..	25
(c) Front-end Loader, Wheeled 2½ cu. yd. cap. . .	20	30
2. Hind Marion Excavators 2.5 to 4 cu. yd. cap. .	30	30
III. M/s. Ashok Leyland		
Dumpers		
(a) Hippo 15-T. capacity	70	70
(b) Beaver, 12-T, capacity	40	40
IV. M/s. TELCO, Jamshedpur		
Excavators 1½ to 4 cu. yd. cap.	60	60
V. M/s. Heavy Engineer Corpn.		
Excavators, 4.6 cu. m. cap. .	10	13

The projected programme for manufacture of indigenous equipment as given above, does not include Crawler Tractors of 50 to 90 h.p., which would be principally manufactured for the Agriculture Department by some other manufacturers not listed here. The consideration in that regard has been excluded from the purview of this note, as the requirements are specifically in relation to the Ministry of Agriculture/Agro-Industries Corporations etc.

If the projected programme as indicated above, does effectively materialise in actual production of equipment, it is expected that equipment worth Rs. 600 million would be produced annually in the country. Taking into account the export potential at about 10 to 15% of the total production, equipment worth Rs. 500 million approx. may be available for home consumption.

The Committee have also been in direct touch with the major manufacturers of equipment as listed above with a view to ascertaining the precise details of the programmes of manufacture of equipment during the years 1972-73 and 1973-74. The information given by them is slightly different from what has been indicated above. Details of the programmes as given by them are as follows:—

Production Programme as given by the manufacturers.

I. M/s. Bharat Earthmovers Ltd.

Equipment	Programme	
	1972—73	1973—74
1. Crawler Tractors		
D-50	100	120
D-80	120	120
D-120	100	120

Equipment	Programme	
	1972—73	1973—74
2. Motor Grader	30	30
3. Motorised Scraper	30	40
4. Dumpers LW-25	40	40
LW-35	120	120
LW-50	20	20
5. Front-end Loader	50	75
II. **Hindustan Motors**		
1. Terex Equipment:		
(a) Dumpers 25-T	94	150
(b) Crawler Tractors 82-40	..	24
(c) Front-end Loader 2½ cu. yd.	20	50
2. Hind Marion 2½ to 4 cu. yd.	58+1	72+4
III. **H.E.C. Ranchi**		
Excavators 4.6 cu. m.	24	24

The projected programme of production of equipment bears a direct relationship to the foreign exchange funds for import of components and the installed facilities created by the manufacturers. Subject to augumentation of the resources and the facilities, the production programmes can also be suitably augmented or enhanced. If emphasis has to be laid on import substitution it may be prudent to make provisions for import of components and for creating facilities to the required extent for accelerating the pace of production of different categories of equipment by the individual manufacturers who are already licensed to manufacture these items. The notional imbalance between the requirement and production would gradually disappear if the production steadily increases. It is only a natural phenomena that availability generates the potential of requirements, specially when machines of good quality and standard are in reference.

5.3.3 *Irrigation and Power Sector—Requirement of Indigenous Equipment*

The Irrigation and Power sector, as in the past, consumed about 30 to 40% of the indigenously manufactured equipment produced in the country. Hence, it may be expected that Rs. 150 million to Rs. 200 million worth of equipment may be available for use in the Irrigation and Power sector annually, against the average annual requirement of Rs. 200 million as per estimate of demands given in para 5.1.4.

During the last two years, for the Irrigation and Power projects, the amount of foreign exchange spent in the import of capital equipment has been of the order of Rs. 13.6 million and Rs. 22 million respectively (the second figure being for the period ending December, 1971). It may be estimated that at an average about Rs. 20 million worth of imported equipment would be required since such equipment is not in production in the country. In fact, only such items are imported as are specially tailored to meet the specific requirements of work on individual projects; and it is economically not possible and viable for indigenous manufacture of such equipment to be developed in the country in view of the very small anticipated off-take by the users. In some cases, such imports are also made when the requirement is urgent and delivery period of indigenous equipment is protracted.

5.3.4 *Important Aspects of Import Substitution Relating to Equipment*

5.3.4.1 *Need for imports*

In spite of best and concerted efforts being made to accelerate the programme of indigenous manufacture of equipment in the country, random demands would always keep arising in respect of some specialised tailor made items of equipment. Such imports are inevitable.

Occasionally in spite of certain items of equipment being manufactured in the country, these may not be available in sufficient quantity and in required time to meet urgent requirements of some of the needy users. In such cases, it is a matter of judgement on part of the purchasers (based on estimated losses that may accrue if in absence of such equipment, the work for which it is required may suffer a serious setback and delay) to import the required equipment. This, however, is not an unremedial situation. What is required is far-sightedness in the matter of planning and scheduling the procurement of equipment so that it is available from the indigenous sources at proper time. Normally panic purchases of capital items of equipment, should not arise.

In such cases of inevitable imports, clear thinking is necessary in one respect, i.e. to import equipment which is similar or identical to the equipment being manufactured. If this is kept in mind in principle, substantial amount of saving in foreign exchange can be made by getting the maintenance parts etc., subsequently from indigenous sources. In interest of national economy, this consideration is of prime importance and should be given the deserving attention. It may perhaps be necessary to issue a policy directive in this regard.

There is yet another aspect to be considered in relation to inevitable imports mainly in respect of items which are already licensed for manufacture in the country. If the manufacture of the licensed equipment is getting delayed because of the effort on part of the manufacturer to organise facilities and resources for contributing a high degree of indigenous content right to start with, it may perhaps be of advantage, in the interests of overall economy, to consider a relatively lower indigenous content to start with. The manufacturer would then start with a minimum of the indigenous content but yet cause a substantial saving of foreign exchange which may otherwise be involved in import of equipment. The main benefit resulting from acceptance of this principle would be that the imbalance between the requirement and supply in respect of equipment would be reduced and furthermore the overall savings in foreign exchange would increase. Besides this, the continuous development of indigenous spare parts for machines will get the necessary boost up.

One such item that can be quoted in example is that of crawler tractors of 400 h.p. capacity. Even though the demand of the users in respect of this item has been steadily increasing, thus necessitating imports, the licensed manufacturers have yet to make a beginning in the manufacture of the item. It is informally understood that it is taking them time to organise the manufacture of this item, mainly because they have to start initially with 60% indigenous content.

5.3.4.2 *Market survey for determining potential of requirement for indigenous manufacture*

Progressive development of indigenous manufacture of equipment envisages better converage of requirement of equipment by type, size, categories and specifications thereof, commensurate with the needs of the users. Until such time the manufacturing programmes come to a stage of fulfilment according to a preplanned programme and cover a requirement oriented product mix etc., it is difficult for the users of equipment to make a selective choice of equipment for overall economy in operations on the job. The manufacturers and the users of equipment have, therefore, to coordinate with each other in enhancing the scope of manufacture by covering additional items at periodical intervals depending upon the potential of demands generated for such items as have not been produced up to a point of time. Experience of the users in the use of such items not previously manufactured, but otherwise put on the job after importing, may clear the way for a techno-economic decision being taken to take up its manufacture. In such a case, the demand of an individual user may only introduce an item but before its manufacture is undertaken, the manufacturer would look forward to make a market survey regarding the potential of its requirement in future, so that the economic feasibility and viability of manufacturing same could be properly judged.

While in respect of certain sizes and models of equipment being manufactured in the country it may not be prudent to take up the manufacture of more recent models of the same equipment as in other countries, at least in respect of such items which have a new technical design and which would prove more economical in operation compared to its counterpart already being manufactured (a machine of different design), it may be worthwhile considering manufacture of such an item.

In Chapter 6, while defining the functions for the Standing Committee for Equipment Planning, the subject of market survey has also been indicated to fall within their purview. That Committee being comprised of representatives of all major users of equipment in the country, can progressively make an assessment about new items of equipment to be introduced for indigenous manufacture in the country after properly evaluating the benefits that could be realised in terms of economy in end cost of production on the job. The Members of the Committee would be in a better position to collectively take a view on the potential requirement of such an item of equipment and the potential of exports etc., in the international market.

5.3.5 *Import Substitution Relating to Spare Parts.*

5.3.5.1 *Imports inevitable*

As in the case of items of equipment, imports are inevitable in respect of spare parts also. In fact, the indigenous content in the indigenously manufactured equipment is generally assessed in terms of value of items manufactured in Equipment Manufacturers' works and of those bought over by him from ancilliary industry in the country. The components, assemblies and spare parts manufactured by ancilliary industry, however, also include some imported content. For a given piece of indigenously manufactured equipment as a whole, the indicated indigenous content is therefore, not a correct base for the measure of the total imported content actually included in various assemblies, components and parts of the machine. The equipment user, in making a clear estimate of the imported spare parts has also to consider the value of identified imported items of spare parts in relation to individual components and assemblies supplied by the ancilliary industry. This unfortunately is not being done clearly at present. This aspect results in a peculiar situation when the Directorate General of Technical Development review individual applications for import of spare parts as initial supply with the equipment. The D.G.T.D. normally allow the manufacturers to import spare parts up to a value of 15% of the imported components as brought in by them. Accordingly, therefore, the quantum of permitted imports do not enable the manufacture of equipment to fully meet the requirements of imported parts of the equipment user.

In order to ensure that an average user of equipment is not handicapped in the matter of maintenance and repair of equipment in the first two years of its operation, it is very necessary that each manufacturer should prepare, with the help of the ancilliary industries supplying assemblies and components, to him, a detailed and clear list of imported parts. Preparation of such lists will help not only in expeditious procurement of the maintenance supplies for the new machines, but will also provide the opportunity of continuous and progressive review of the lists for enhancing the scope of indigenous manufacture of these items, if these are required in large numbers.

5.3.5.2 *Assistance from users and dealers of equipment for development of indigenous manufacture of spare parts*

This aspect has been dealt with in details in Chapter 6 Para 6.8. However, a few important points which have attracted the attention of the Committee may be mentioned with regard to the quality of the indigenously manufactured parts. The main items which need specific mention are the following:—

(a) Hydraulic system components and parts.
(b) Torque Converters.
(c) Diesel engines.
(d) Tyres.

(a) *Hydraulic system components and parts.*

The latest trend in development of equipment manufacture in foreign countries shows progressive use of high pressure hydraulic systems. The components and parts for such high pressure systems require a high degree of precision in their manufacture. So far satisfactory development has not been made in this respect in the country. Considering that some major items of equipment, like excavators and cranes may take the shape of hydraulic machines—with hydraulic motors used for various operations of the machine, thus reducing the mechanical components etc., serious efforts would have to be made in giving the required fillip to this industry.

(b) *Torque converters.*

The indigenous torque converters have been a source of persistent trouble to the machines on which these are used. The manufacturers are no doubt, making a continuous research so as to localise the areas in which faults are occuring and to take necessary corrective action. But it has taken fairly long for satisfactory results to be achieved.

(c) *Diesel engines.*

A reference to this point has already been made in Para 8.2.9.7 of Chapter 8.

(d) *Tyres.*

The tyre manufacturers in the country have in the past several years undertaken manufacture of different sizes of heavy 'earthmover' tyres for different items of tyred equipment. They have gradually improved the quality of the product; but the performance of some sizes of these tyres has not come to match the performance of corresponding items of imported tyres. Tyres for heavy earthmoving machines being a very expensive item, it is very essential that the tyre manufacturers take meticulous care in so processing the rubber and the construction of the tyres in the course of their manufacture that the resultant product may give good as performance as of the imported tyres.

5.3.5.3. *Observation of committee.*

The Directorate General of Technical Development the CW&PC, the Directorate General of Supplies and Disposals and the major users of construction plant and equipment in the country, have in the recent past made vigorous efforts in the direction of import substitution in relation to spare parts for such equipment. Assistant in this matter has been sought from the dealers of equipment/agents in India of the primary manufactures of parts abroad, for identifying the items which can be conveniently manufactured in the country. On rough reckoning basis, the value estimate of the parts being manufactured for earth-moving machines etc. is Rs. 40 million approximately annually. Further programmes have also been finalised for adding another 1500 to 2000 items to the list of indigenously manufactured spare parts during the year 1972-73. This would account for a further addition by value Rs. 10 million annually.

Since the overall requirements of spare parts for maintenance and repair of the equipment operating in the country, is much more than what has been so far covered indigenously, the DGTD has initiated proposals for setting up an agency who would identify, (i) the additional items of spare parts, that can be indigenously manufactured; and (ii) the sources/manufacturers who would be able to readily undertake the manufacture thereof. This aspect has been dealt with in para 6.8.4 of Chapter 6. Necessary details of the proposals under consideration have also been given therein.

The value of imports of spare parts, necessary to keep the available equipment (mainly earthmoving machines) in proper working order for optimum utilisation is estimated at Rs. 60 million to Rs. 80 million (c.i.f. value) annually. This value figure clearly signifies the quantum of spare parts which has to be produced if import substitution is to be achieved in real sense.

In relation to the item of tyres, in the Irrigation and Power Sector alone the imports during the last two years have been of the order of Rs. 6 million. Though, it has not been possible to get the figures of value of imports of tyres on country-wide basis, it may not be wrong to assume that the total value of such imports of tyres may be taken at 150% of the figures of imports for the Irrigation and Power Sector. Some serious consideration may therefore, be called for to determine if some more sizes of tyres required for earthmoving machines etc., are to be manufactured in the country. No doubt for the indigenously manufactured equipment, only such tyres are fitted on the machines which are available within the country; and therefore, the imports would mainly relate to tyres for imported equipment only. Yet, if certain pneumatic tyred machinery has necessarily to be imported in absence of any manufacturing programme thereof in the country, for long term planning it may be profitable to identify the sizes of tyres which should be added to the existing lines of tyres production.

It has also been observed by the Committee that such imports of tyres have been made even in sizes which are manufactured in the country. This has resulted from comparatively shorter life of the indigenous tyres on the job; and the increased demand (for replacement) has consequently come up earlier than expected, which the manufacturers have not been able to adequately meet.

Sometimes, the shortage has also resulted from non-availability of some of the raw materials for manufacturing the tyres—in the past nylon cord was in short supply. With a view to conserving foreign exchange resources, it is necessary that provision in respect of raw materials for tyre industries should be adequate.

5.4. Standardisation

Various aspects of standardisation which are of importance to the users of equipment in the country, mainly in relation to the imported equipment, have been already dealt with in different Chapters. In relation to imported equipment, the main consideration so far has been the comparative performance of items of equipment of various makes from different countries of origin. From stand point of the users of equipment, who have to consider mainly the aspects of engineering economy and economy in construction costs, there are many other facets to be considered in this connection. These are as follows: —

I. *Economy in investment costs resulting from*:

- (a) Selective choice of proven equipment of standard design.
- (b) Reduction in the number of standby units.
- (c) Reduction in inventory of spare parts and ease in forecasting requirements thereof.
- (d) Reduced maintenance effort.
- (e) Specialisation in repairs, rebuilding and conservation of components.
- (f) Equipment and facilities for maintenance and repairs.
- (g) Better development of modifications in the design and construction features of the machine at lesser expense on research work.

II. *Economy in cost of end products produced by machines by virtue of*:

- (a) Better performance of machines and consequently better utilisation and better productivity.
- (b) Lesser breakdowns and down-time.
- (c) Lesser expense on training of personnel for operation and repairs.
- (d) Least cost of maintenance and repairs.

III. *Economy in costs of improvement methods for overall management of equipment through*:

- (a) Time and methods studies.
- (b) Methods analysis techniques.
- (c) Operation and research studies.
- (d) Evaluation of cost data.
- (e) Equipment replacement policies.
- (f) Uniformity in pattern of record keeping with regard to history of performance of machines, cost data, specifications, maintenance and inspection.

It may not be necessary to explain the significance of each one of the items listed above. These have been otherwise referred to directly or indirectly in details in Chapter 3, 4, 6 & 8. It may also be indicated that the basic idea of standardisation is to buy units of economy. But the responsibility in this regard it is equally with the user/buyer of the equipment and the manufacturers of equipment. Whereas the user has necessarily to be conscious of all the factors listed above, if has to efficiently manage the equipment operations and utilisation, the manufacture must make the equipment so, that the economy of design, inter-changeability, material, production, perfection, size, and simplification are integrated therein.

5.5. Summary of observations and recommendations.

Any exercise of assessment of requirements of equipment relative to a defined activity involves consideration of adequacy or inadequacy of the available equipment, the equipment replacement policies and the additions of equipment necessary for augmenting the new identified schemes of development. A conclusive thinking on these considerations can be finalised subject to availability of resources. These would include financial allocations, availability of equipment within the country, foreign exchange for import of equipment etc.

The uncertainty about the adequacy of these resources to meet the requirements according to scheduled programmes, has been a major handicap in making a precise assessment of the requirements of equipment in various sectors.

During the last five years or at least during the 4th Plan period, the emphasis has been on completing the work on the continuing schemes. New development schemes have mostly come to the take off stage only now. To the extent these schemes have been identified, an assessment of requirements of equipment could be made.

The equipment replacement policy is closely related to the availability of equipment from indigenous sources. The pace of development of the indigenous manufacture of equipment having also got rather restricted and the availability of foreign exchange for import of equipment having been scarce, an average user of

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equipment has had to physically live with the equipment as long as it could last on the job. The consideration for economic replacement of equipment has not been of primary importance. Clear forecasts of equipment replacement have also therefore not been possible.

Since we are already in the 4th year of the 4th Five Year Plan, the assessment regarding requirement of equipment for the remaining two years of the 4th Plan period, has been made based on the available data. The estimate of requirement is Rs. 700 million approximately, or Rs. 350 million per year for two years. This is in relation to Irrigation and Power, Iron-ore Mining and Coal Mining sectors.

The additional requirement of equipment of other sectors, namely, Road Building, Lignite Mining, Agriculture, Cement, Land Reclamation and the private sector, may be estimated at Rs. 450 million per year. This does not account for the requirement of DGBR and Defence.

Considering the performance of the manufacturers of major items of construction plant and equipment in the country over the past three years, it can be observed that partial imports of some items of equipment will be inevitable.

In respect of spare parts, even though substantial progress is revealed in their indigenous production over the past three years, the majority of equipment in use in the country at present being of imported origin, the requirements of imported spare parts would be of the order of Rs. 60 million to Rs. 80 million annually, if proper utilisation of the equipment is to be ensured.

Recommendations

1. Programmes for indigenous manufacture of equipment should be suitably augmented so as to adequately meet the requirements of major users of construction equipment in the country. Unless this is done, import substitution will not get the required impetus and precious foreign exchange would have to be spent for continued import of even such items as are otherwise in production in the country.

2. Greater emphasis should be laid by the indigenous manufacturers on quality control of the products. In addition, a continuous research programme should be developed for improving the design and construction features of the machines, so that we can keep pace with the technological developments in the field of manufacture of such equipment abroad. The improved machines should give greater productivity at lesser cost of maintenance and repairs.

3. Until such time there is larger population of indigenous equipment in the country and the imported equipment ages out to the point of its replacement by indigenous equipment, liberal sanctions of foreign exchange be issued for importing maintenance and repair parts. The level of imports has to be sustained by annual allocation of foreign exchange funds in a uniform manner—a minimum of Rs. 60 million, per year.

4. To promote import substitution in respect of spare parts, an earnest effort has to be made for precise assessment of the potential of requirement of such items of spare parts as are required in large numbers every year, so that economic feasibility aspect of adding more items to the list of indigenous spare parts is established.

5. For optimum utilisation of the equipment within the very first two years of its commissioning on the job, adequate supply of spare parts should be ensured by the indigenous manufacturers. Since this will also involve imported items of spare parts, restriction in the import of such parts for initial supply with the machines should be relaxed as far as possible, unless the indigenous sources are clearly identified by the manufacturers or by the ancilliary industry.

6. The term "Standardisation" should be given the required amount of importance it deserves. The economy resulting from standardisation should be properly evaluated not only relative to the selection of equipment for its first purchase, but also to all other aspects which get involved in management, operation and utilisation of machines.

CHAPTER 6

Inter-departmental coordination in matters relating to Construction Plant & Equipment with emphasis on inter-departmental transfer of surplus equipment

6.1 Necessity for Coordination

6.1.1 *Avoiding Underutilisation*

In Chapters 1 and 2, a clear summation has been done of the factual information relating to variety of construction plant and equipment in use in the country, their performance in general, and the level of utilisation of equipment is obtaining with various users in different sectors. The effort made by the equipment owners even for rendering the information regarding utilisation of equipment etc., has revealed the necessity for uniformity in maintenance of records so that a quick appraisal and comparative study can be made whenever the occasion arises to do so. The underutilisation of equipment with most of the owners of large fleets of equipment has gravitated the consideration that if under-utilisation of such equipment is even partially attributable to excessive holdings of equipment by various users, there should be a means of communication amongst the equipment owners, so that they can draw upon the available resources in the country (in form of surplus holdings of equipment) in times of need. Such surplus holdings can be gainfully used on certain jobs of comparatively smaller durations which can ultimately help in avoiding additional capital investments on new equipment for such jobs, where again, after the job is completed in a short time, such equipment would grow surplus and may lie idle.

Hence, with the basic objective of optimum utilisation of equipment and for expedition and economy in the jobs where it is to be used, it is most essential that there should be a close liaison and co-ordination amongst most of the major users of such equipment in the country. Emphasis, no doubt, evidently becomes necessary more on the utilisation of the available resources in interests of overall economy in any new investments to be made. In that context, the rehabilitation and deployment of surplus equipment and spare parts in the country becomes more important. This is what has been greatly stressed even by the Committee of Ministers constituted by the Government to recommend measures for elimination of delays in procurement of construction equipment and spare parts required for Irrigation and Power Projects in their recommendations.

6.1.2 *Procedure and Policies*

Further more, in the matter of processing the indents for equipment and spare parts, there are a variety of problems commonly faced to meet the procedural and policy regulations governing the same. If each individual department/Public Sector Undertaking/user of equipment attempts to find a solution to the problems facing him in this respect, the total effort involved in overcoming such problems would be colossal if reckoned on cumulative basis. If the position is, however, reviewed for rational analysis of the problems involved by a co-ordinating agency with a view to finding suitable remedial measures which may entail expedition in procurement of equipment and spare parts or other maintenance supplies, taking into account the problems collectively faced by most of the equipment owners/users, the net resultant revision in procedures and policies would be quicker and would benefit all of them.

6.1.3 *Improvement of Construction Methods and Techniques.*

In relation to progressive improvement in construction methods and techniques and maintenance engineering in relation thereto, or in the fields of utilisation of such equipment in any sector—Irrigation and Power, Iron Ore

Mining, Coal Mining, Road Building, Land Reclamation etc., etc., there has to be a system of exchange of views on technical matters with a view to simplification, standardisation etc., etc., so that the basic techniques of work improvement may go unknown and unheeded with the inherent competition that the construction industry would progressively face in the context of the growing economy of the country. To achieve this objective also, it would be only rational that there is close coordination amongst various owners/users of equipment. This would help immensely in continuous improvement of the methods and techniques of work with equipment.

6.2 Subjects of Interdepartmental Coordination

The important points which would attract reference in this context for inter-departmental coordination may be listed as follows:—

1. Basic planning for equipment—assessment of requirement based on practical norms of production, selective choice of equipment, relative to fields of application or work where it will be used, operation, maintenance and repair of equipment, inventory control of spare parts etc., etc.
2. Utilisation of surplus equipment by timely disposal/rehabilitation/transfer other needy users to save additional investment on new equipment, simultaneously utilising the blocked up capital already invested on such equipment.
3. Determination of availability of spare parts for like items of equipment with various users in the country, to provide ready availability of some of the vital parts which being available at some locations, may serve to commission some idle equipment elsewhere.
4. Interchangeability of parts relative to different makes and models of machines.
5. Indigenous manufacture of spare parts—facilities and capability of different organisations in this respect and the outside sources and private sector relating thereto.
6. Liaison with Industrial Development Department of Ministry of Industrial Development and the Directorate General of Technical Development in matters relating to indigenous manufacture of equipment and spare parts and clearance for import of parts and equipment that are not manufactured in the country.
7. Liaison with the Directorate General of Supplies and Disposals and the Chief Controller of Imports and Exports in the matter of procurement of equipment and spare parts as well as import thereof.
8. To lay out the frame work of formalised training programmes.
9. Updating and revision of norms relative to production by different items of equipment under different situations and their utilisation.
10. Collection of data on repair costs of equipment.
11. Standardisation of equipment through collection of performance data.
12. Management and control of equipment.
13. Evolving a unified pattern for record keeping in relation to performance of equipment and cost accounting.

Most of these points have been individually dealt with in this report in context of different terms of reference set forth for the Committee in chapters relating to each. Hence, it is not intended to enlarge upon these points in elaborate details in a repetitive manner. The main emphasis having to be on rehabilitation or departmental transfer of such equipment, this point will be mainly elaborated, while the significance of the other points will be briefly discussed, from the standpoint of their functional importance to the owners of equipment collectively, in subsequent paragraphs of this Chapter.

6.3 Coordinating Cell

6.3.1. *Need*

It may be appropriate to consider feasible ways and means to establish, in an effective and successful manner the inter-departmental/inter-organisation coordination, so that the envisaged functions as listed above, could be properly performed. Primarily this would indicate the need for establishment of Coordinating Agency/Cell to be established or created at the Centre—if necessary under the aegis of one of the major Sectors using the largest fleet of equipment.

The Committee of Ministers also had recommended in their Report that the Mechanical Organisation in the CW&PC should be strengthened so as to effectively coordinate with the State organisations in various matters incidental to the use of construction plant and equipment in the Irrigation and Power Sector. This coordinating cell is further recommended to establish liaison with other users of equipment in the country—specially Mining, Steel, Transport Departments etc., so that there could be proper exchange of views on common matters relating to use of such equipment in various fields and sectors in the country.

6.3.2 *Present arrangement.*

To some extent, such activity for inter-project and inter-State coordination is being performed in the Irrigation and Power Sector through the Central Water and Power Commission under the Ministry of Irrigation and Power. In that sector at the State level, Central Mechanical Organisation have been set up or are being set up. Details in this respect are elaborately given in Chapter 12.

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Interdepartmental coordination with regard to certain aspects of standardisation of equipment has been done in the past through a Standing Committee of Experts on Standrisation of Earthmoving machines. The Committee was constituted by the Government under the Ministry of Irrigation and Power, in January, 1954, and consisted of representatives of all major users of earthmoving machines in different sectors in the country. The List of members constituting the Committee is at Appendix 6.1 (as last published by the Ministry of Irrigation and Power).

The examination of the question of standardisation was specified to be with reference to the following points:—

1. It should be ensured that neither inflation of prices, nor other disadvantages result from the proposal of standarisation.
2. Equipment manufactured in India should get overriding priority as soon as it is available in the country.
3. Safeguard should be provided against any adverse results arising out of monopolistic tendencies.
4. The number of standardised makes of equipment should normally be from two to five, those limits not being wholly binding in each case.
5. The interested firms should be given an opportunity to represent.
6. It should be ensured that manufacturers whose equipment is standardised carry adequate stocks of spare parts and enter into price agreements with the Director General of Supplies and Disposals.

For various reasons, as discussed in Chapter 1, the Committee could function only under some limitations arising in consequence of limitations imposed in import of equipment from some of the known sources of origin of equipment and Trade Agreements with 'Rupee Payment Area' countries. The functions of that Committee would now be performed by the proposed Equipment Planning Committee.

6.4 Standing Committee on Equipment Planning—Need for establishment and functional relationship with other Coordinating Agencies/Establishments.

Once the plant and machinery has been purchased, erected and commissioned, one has to live with it for years. The desired benefits of trouble free performance, utilisation and economy in costs will generally be commensurate with the amount, of attention paid at planning stage in selection of equipment, proper design of plant lay out and facilities and scheduling of the programme of work. It has, however, been revealed by studies of collected statistical data that low efficiency in utilisation of equipment with an average user has resulted in non-attainment of production targets and much higher investment than was originally envisaged. The reasons for such under-utilisation of equipment have been clearly analysed in Chapter 3. The remedial measures, as already outlined in the same Chapter, call for very close liaison and coordination with a number of agencies/departments/Ministries for simplifying rules, policies and procedures, besides updating of information relative to performance data of various makes and categories of machines, norms and standards of production and costs, so that future planning of equipment can be more successfully done to ward off any possible delays in operational time of various activities involving use of equipment.

To achieve this, it is basically necessary to pool the information collected by the users of equipment in various sectors so that this can be used to advantage by all concerned. Further more, in interests of economy starting initially with reduced investment towards equipment costs and maintenance supplies, pooling of resources by way of equipment and spare parts etc., is also called for. A practical means to achieve these objectives would be to establish a Coordinating Agency enlisting participation of major users of equipment in different sectors in the country. This agency besides establishing proper liaison with Government Departments/Ministries in respect of rules, policy and procedural matters, will be principally involved in reviewing the plant planning exercises carried out by the individual projects/organisations. This agency may be given the form of a Standing Committee on Equipment Planning. This will be referred to as Equipment Planning Committee hereinafter.

With the functioning of the Equipment Planning Committee, it would be convenient to make assessment of requirements based on practical norms of production, standardisation of equipment and various other considerations relating to technical acceptability of design and construction features of particular items of equipment to be selected to match the job requirements.

Before defining the constitution of the Equipment Planning Committee and its functions, it would be necessary to identify the establishments who will be associated with it. These are,

1. In the Irrigation and Power Sector, the Central Mechanical Units which have either been established in certain States, or these are in the process of getting established in other States.
2. The Equipment Planning Committees of individual Projects/Departments whether in public enterprises or in the States, or under the Central Government

   (These two have been explained in Chapter '12')
3. The Plant Planning Directorate proposed to be set up under the Central Water and Power Commission.
4. The Central Coordination Cell referred to in para 6.3 preceding.

The inter-relationship between the Equipment Planning Committee and these identified establishments will be as follows:—

The Equipment Planning Committee will draw all the information required for study/decision on any case referred to them from the Central Coordination Cell. This Cell shall be receiving data from the Central Mechanical Units in the States and other Sectors, and shall be classifying this information for ready availability to the Plant Planning Directorate as well as the Equipment Planning Committee. The Central Coordination Cell shall also supply data required by the Equipment Planning Committee of Individual projects/departments, whenever such data is needed by them for the formulation of new proposals for equipment purchase or for a review of the performance of equipment at any project.

The Plant Planning Directorate of CW&PC shall serve as the reviewing body for all proposals received from Equipment Planning Committee of individual projects/departments, or from Central Mechanical Units; and shall arrange to finalise these proposals on the basis of data supplied by the Central Coordination Cell, the proposals having to be put up to the Plant Planning Committee for finalisation on the basis of a second review. In respect of Plant Planning proposals from Sectors other than the Irrigation and Power, the Plant Planning Directorate shall provide supporting office service in the process of review of these proposals by the Equipment Planning Committee.

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6.4.1 *Existing Practice in Irrigation and Power Sector*

In so far as the Irrigation and Power Sector is concerned, as at present, the Equipment Planning Committees of some of the projects take a second look on the proposals in consultation with the CW&PC and sometimes other consultancy organisations. However, there is no uniform basis for proper introduction and enforcement of a common basis of assessment of requirement of equipment, selection of particular system of work with equipment on a given job—specially the economy aspect of it, and the phasing of programme of work on realistic basis for precision in determining the quantum of equipment required or the type of equipment required.

6.4.2 *Participation by All Departments*

While the CW&PC are in the process of setting up a new Directorate for Plant Planning, the functions to be performed by that organisation, may cover only a part of the problem and until such time the experience gets developed to the required extent, the examination of plant planning exercises would be of a limited nature—the extent of production by suggested items of equipment, cycle time in operation of equipment etc., etc. Here again, unless a wide variety of information relating to performance of equipment under varying job conditions and situations, is compiled and used for reference in the process of second check on plant planning exercises, the objectives in view would not be fully realised. Compilation of such information from various users of equipment in the country, outside the Irrigation and Power Sector, would call for participation of other Departments concerned using similar equipment. Such participation could be made possible only if representatives of major users of equipment can work together in the proposed Equipment Planning Committee. The experience of each one of such representatives could be shared mutually by all members of the Committee and their joint deliberations, in matters relating to plant planning for giving items of works, could be expected to entail good deal of economy in investments of equipment in any field where the equipment has to be employed.

6.4.3. *Constitution*

The constitution of the Committee may be briefly outlined as follows:—

Chairman

Members: 2 Nos. Mechanical Engineers and 1 No. Civil Engineer,

to be selected from the following:—

(i) National Mineral Development Corporation

(ii) National Coal Development Corporation

(iii) Irrigation and Power Projects

(iv) Ministry of Transport

(v) Other Central/State Government Departments

(vi) D. G. B. R./Engineer-in-Chief Branch Army Headquarters.

4th Member:—Senior Officer controlling the Plant Planning Directorate in the CW&PC.

Only periodic meetings of the Committee may be held—once in two months and for '3' days at a stretch to finalise cases, earlier referred to the 'Members' by circulation of notes. The Plant Planning Directorate would function as the Secretariat of the Standing Committee, while for individual Equipment Planning Committees, for particular projects, Chief Engineer, Project, will arrange for the Secretariat work.

The Chairman of the Committee may be a Member from the CW&PC, or, an officer of some other organisation of a similar status. Whenever the 'Plant Planning' proposals of any project are to be dealt with by the Committee, the head of the project (Chief Engineer/General Manager), may be associated as a Member. He will also provide necessary secretariat assistance with respect to the work of the project.

6.4.4 *Functions*

The functions to be assigned to the Committee may be broadly outlined as follows:—

(1) Examination and assessment of requirement of equipment on new projects in Irrigation and Power Sector.

(2) Prescribing norms/work standard units etc., for work with equipment;

(3) Systems analysis for economy in work with equipment on projects;

(4) Advice regarding manpower, their training, maintenance engineering, inventory control methods, record keeping etc., on unified pattern basis.

(5) Advice to all users of equipment (when called for), in different sectors, including Public Sector, on 1, 2 and 3 above.

(6) Vetting of demands for additional equipment with due consideration to the existing equipment available with the indenting departments.

(7) Trends in development of equipment and methods and techniques of their use abroad—updating of information for gainful use.

(8) Liaison with the DGTD and Industrial Development Department regarding:

   (i) New items of construction plant and equipment to be undertaken for manufacture;

   (ii) Review of production of indigenous equipment—production levels, demands, quality of product, performance of equipment—in specific context of reports from users, and the consequent recommendations for improvement, planning for indigenous manufacture of spare parts etc., and standardisation of equipment.

(9) Liaison with the DGS&D in the matter of:

   (i) Rate Contracts for indigenously produced components and spare parts for earthmoving machines, diesel engines etc.

   (ii) Rate Contracts for imported items of spare parts—the technical aspects mainly in relation to 8(i) and 8(ii).

(10) Standardisation of Equipment.

With a view to ensure that the Committee functions effectively, it would be necessary to vest authority unto them in the matter of technical decisions.

6.5. Interdepartmental Transfer of Surplus Equipment

6.5.1 *Difficulties in Transfer of Surplus Equipment*

The guide-lines for transfer/disposal of surplus equipment in the River Valley Projects were laid down by the Ministry of Irrigation and Power/CW&PC consistent with the recommendations made during Irrigation and Power Engineers Seminars and the subsequent decisions taken by the Coordination Board of Ministers. These were later published in the book under the same title which has so far been used for reference for determining the transfer/disposal value of the surplus machines. These guide-lines had undergone revision on a few occasions in order to rationalise the procedure for convenience of quick transfer of the surplus equipment to needy projects.

All the same, the prospective transferees of surplus equipment have shown reluctance to accept such surplus machines for various reasons. The main difficulties faced by the owning project in quick disposal of the machines are as follows:—

(1) Surplus machines are either unserviceable in condition, or have not been maintained properly.

(2) Transfer/disposal value of the machines is considered excessive in relation to the actual physical state of health of the machines.

(3) Standardisation of equipment is a predominant consideration which necessitates selective choice of machines to be added—whether new or old.

These points are explained in details as follows.

6.5.1.1 *Poor state of health of surplus machines*

The study made by the Construction Plant and Machinery Committee reveals that even though the available equipment is extremely under-utilised on some of the projects, none has considered the proposition of laying off even in part, some of the available machines and utilising more intensively the balance of the machines. It is believed to be a popular concept with most of owners/users of equipment that the equipment is surplus only when it grows

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to be in unserviceable condition or beyond economical repairs. The relationship between the job requirement and total availability of machines is not fully comprehended or at least not closely examined. In fact, there is a general tendency on the part of some of the projects to somehow cling to such equipment for as long as possible, and, not to declare it surplus at the right time to make the proposition attractive enough for other prospective buyers.

Another eventuality in which the machines are considered to grow surplus, is the completion of a project or a work for which the equipment is purchased. It is in such cases that scanty attention is paid to the upkeep, repair and recommissioning of the machines for subsequent gainful use on some other work. Most of the owners of equipment are mainly led away by the consideration that the equipment having to be sold on "as is where is basis", it should be the responsibility of the prospective buyer of such equipment to recondition the machines in a manner they would think it best to do, commensurate with their job requirements. It is this implied apathy to the otherwise warranted upkeep of the equipment which distracts most of the prospective buyers to acquire such used surplus equipment.

One of the impediments in sale and purchase or transfer of such equipment from one project/organisation to another, results from creditability gap existing between the transferer and the transferee in relation to the actual state of health of the equipment. Here again, the popular belief is that the equipment offered for transfer or for disposal of any equipment owner, would not be in good condition and for that reason alone, the owner may be offering it for transfer/sale. They feel that the transferer project might not have been able to run the equipment productively and as a result thereof, one would be trying to pass on the equipment to someone else. The Committee, in fact, feels that there is a clear and discernable feeling of antipathy on part of most of the project authorities to take to the use of such surplus equipment which has been in partial use before. In some extreme cases, certain project authorities, even within a State, have shown reluctance for taking over such used equipment on transfer after one of the projects get completed.

6.5.1.2 *Transfer/Disposal value of equipment*

Even though the CW&PC had published a Guide Book on Disposal/Transfer of Used Equipment, for guidance of the River Valley Projects in the matter of acquiring surplus/used equipment on transfer from another project, there have been long-standing disputes between the transferer and the transferee project in the matter of settlement of transfer prices. No doubt, as a result of joint deliberations on part of the Irrigation and Power Engineers in different Seminars, the rules for transfer of equipment and for fixing of transfer value etc., have undergone change from time to time, in view of the practical difficulties encountered by the transferer and transferee projects in the matter of settlement of transfer prices. By and large, the rules as they existed at various stages, were not truly followed in practice, thus resulting in such long-standing disputes about the settlement of transfer values. Even though as a last resort, it was indicated that the transfer value of machines would be a figure of price mutually agreed upon or decided upon by the transferer and transferee projects, thus involving more of a personal discretion on part of those making such assessments, a smooth sailing in this direction has not happened. Accordingly, everyone looking for equipment on a new job had preferred to go in for new equipment rather than to take some old surplus used machines even when such equipment was needed there for short periods at the time of commencement of work.

Many of the organisations/projects generally insisted on making the present-day market value of a machine as the basis for assessment of transfer/sale value. Most often, such consideration is divorced from the aspect of the actual state of health of the machine, which otherwise has to be the main criterian. Very little thought, if any, is given to the fact that if in the earlier stages of the use of the machine, the repair costs were comparatively lesser and the transferee project would have necessarily to incur large amounts of expenditure on maintenance and repair of the machine during its use with him after transfer, there should be some concession to be given to the transferee project by way of reduction in the assessed price even if it is related to the present day value thereof, so that it is not uneconomical for the transferee project to own and operate this machine on his works.

6.5.1.3 *State of health—the arbiter*

The transferee projects have also, most often, doubted the correctness of the records maintained by the transferer projects in relation to items of equipment being transferred/sold. These doubts arise mainly in consequence of the poor state of health of the machine under disposal, because of lack of maintenance and repair of the machine after it was surplus from the work, is in an apparently bad state of health. Some times, even if the records are correctly maintained and the figure of operational hours as shown in the records are correct, the standard of maintenance and repair of the machines during the previous period of operation having been rather poor, the state of health at the time of its transfer/disposal, would not be in consonance with the recorded operational life.

6.5.1.4 *Standardisation of equipment*

Another important aspect to be considered is the lack of standardisation of equipment in the country. This has been dealt with in fairly elaborate manner in the Chapter 1 on "Appraisal of Equipment". However, the difficulty faced by project authorities in taking old surplus used equipment for their works, is that the available items of surplus equipment may defeat the purpose of standardisation on the new jobs for which the equipment is to be purchased. This would be more pertinent to the case of such organisations where the equipment is employed, on continuous basis for production work—For production of marketable commodities like Iron Ore, Coal, Lignite etc. In the normal running of any production work, one has certainly to consider that equipment in good working shape alone would enable the project authorities to fulfil the commitment for maintaining certain levels of production; and the old equipment interspersed in the fleet of available new equipment would largely handicap attainment of this objective.

Since the imported equipment will be gradually replaced by equipment of indigenous origin, and the equipment of indigenous origin, as at present, offering only a limited number of makes and models of machines in each category for the future, the standardisation aspect would be taken care of better. This consideration would not then be of paramount importance in taking over surplus equipment unless of course, the surplus machines are in poor state of health. In the interim period, until the equipment concurrently in use at various projects does not grow to make a homogenous fleet, it should be the effort on part of all users of equipment in the country not to set aside the consideration of using the surplus machines, if the 'National Economy' is to be the prime consideration.

6.5.2 *Observations of the Committee*

Most of the items of equipment in use in the country being of imported origin—at least 70% of the available equipment—the country can illafford nonutilisation of equipment which has the potentiality to produce while procurement of additional equipment is being simultaneously made at higher acquisition cost often involving large sums of foreign exchange.

With the technical know-how, skill and proficiency attained by most of the users of equipment in the country in operation, maintenance, repair etc., of the equipment, it should be reasonably expected that the prospective buyer of equipment—the transferee project/organisation should be on a sound technical footing to reject a surplus used machine only if the value to be paid by him is not commensurate with the 'Mechanical State of Health' of machine. They must think rationally about the investment already made upto the machines available, both by way of capital cost and the amount of foreign exchange expended to import the machines.

Even if a given item of equipment may not fit into a new job requirement (if the consideration is to match its rated specifications to the job requirement), it could be at least alternatively considered to be used for a comparatively lighter duty. In this case, consideration of the 'obsolescence aspect' of the machine does enter; but it does lead further to the consideration that such obsolete machines (based on relative consideration of rated specifications and job requirements), can always be adopted for use on lighter duty work, specially when such lighter duty works are clearly in sight on the new job.

6.5.3 *Fixation of Price of Surplus Equipment*

In the context of what has been stated at paras under 6.5.1 regarding reluctance on the part of equipment users to accept surplus equipment, what is necessary is to so determine the transfer value of equipment that the transferee project does not think that he is carrying a big financial burden by buying a used machine. He generally considers that on one hand, he might pay a fairly high price therefor, and yet get lesser return therefrom in terms of production, with higher cost on repairs. This is a direct result of accounting for depreciation by straight line method on hourly cost basis.

Taking into account all the considerations as outlined above, the Committee have been led to the thinking that if the rated or scheduled life of the machines is fixed in 'number of years', and if depreciation is accounted for on yearly basis by 'Declining Balance Method', the transferee project will be in a happier position when he evaluates the transfer value so assessed side by side with the likely cost of repairs that he will incur when he uses the machine subsequently on his job. Given below are two graphs illustrating the ownership costs accruing to an equipment user (summation of depreciation costs and repair costs of machines), if depreciation is accounted for on hourly basis at a flat rate and also if it is reckoned by Declining Balance Method on yearly basis.

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A comparative study of the two graphs would clearly illustrate the fact that if Declining Balance Method of Depreciation is followed, and transfer value of machines fixed accordingly, the transferee project would not have much to lose even if larger amounts of repair expenditure are taken into account in the subsequent period of use of the machine on a new job.

If the method proposed in the preceding para for evaluation of transfer value is followed in practice, the records to be maintained regarding operational hours of machines may not be of too great consequence in determining transfer value of machines. No long-standing disputes may then arise in the matter of deciding and settling the transfer value. Here again, however, the main consideration has to be the 'Mechanical state of health' of the machine. The previous owner or transferer project cannot disown the responsibility of keeping the machine in good working order in spite of its intensive use during the period he has employed it on his work.

The above would provide a uniformity of basis for assessment of transfer value of surplus/used equipment and would enhance the scope of inter-project/organisation coordination in the matter of utilisation of such surplus equipment in preference to additional heavy investments on new equipment even for short duration jobs.

6.5.4 *Central Coordination Cell for Transfer/ Disposal of Surplus/Used Equipment*

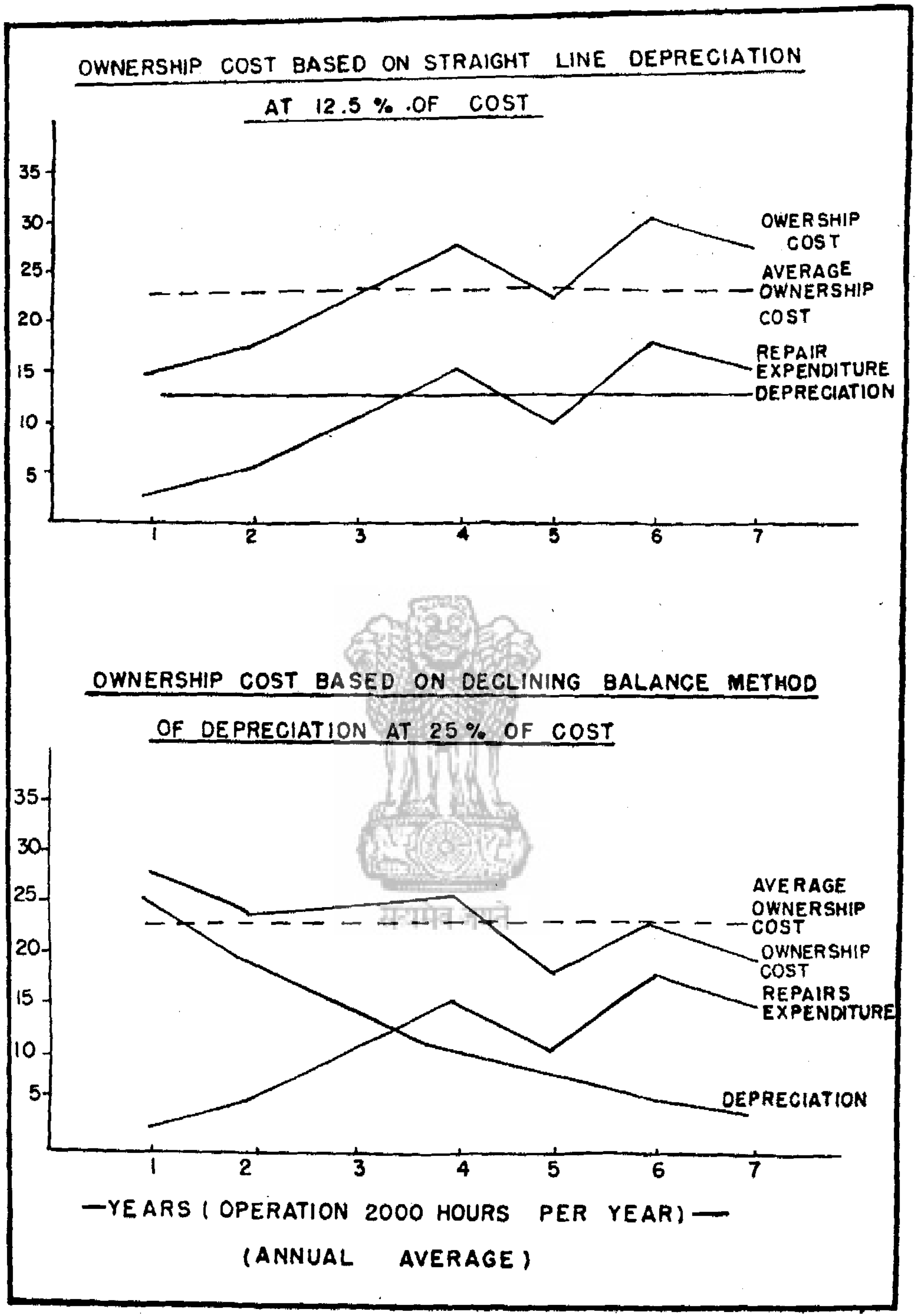
In their Report, the Committee of Ministers constituted to recommend measures for elimination of delays in procurement of construction equipment and spare parts required for Irrigation and Power Projects, have recommended that the Central Water and Power Commission should create a Cell which should serve as the Coordinating Agency for affording the convenience of inter-project/inter-organisation coordination for disposal/transfer of surplus equipment and spare parts. It is highly important that the proposed Cell should play an effective role in coordinating transfer and disposal of underutilised/surplus equipment.

That Cell hould have a 'Master Record' of all such equipment with different users in the country and should be posted with information regarding their utilisation in their respective fields of use. Once the Cell is effectively formed and is functioning, its advice about the state of health etc., of the equipment, is also likely to be more easily acceptable by the transferee projects.

6.6 Coordination in determination of availability of spare parts for like items of equipment with various users in the country

6.6.1 *Present position*

As at present, most users of equipment carry individually large scale inventories of spare parts for the machines in use with them. Identical or similar machines are in use elsewhere in the country with other users. There being no system of exchange of information regarding items of spare parts carried in stock by individual users, most often, when certain required parts are available with one or more users of



OWNERSHIP COST BASED ON STRAIGHT LINE DEPRECIATION AT 12.5 % .OF COST

OWNERSHIP COST BASED ON DECLINING BALANCE METHOD OF DEPRECIATION AT 25 % OF COST

—YEARS (OPERATION 2000 HOURS PER YEAR)—
(ANNUAL AVERAGE)

similar equipment elsewhere in the country, other users keep on indenting these items for procurement through import from abroad. Thus, while stocks of some items of spare parts available in the country are in idle storage in some places, additional investments are made by other users in procurement of these parts. This results in downtime of machines and loss in production despite availability of parts in the country. Consequently, there is also a heavy drain on foreign exchange resources through additional imports of parts.

6.6.2 *Coordination in Exchange of Information*

It is, therefore, necessary that there should be close co-ordination amongst major users of equipment in the country in the matter of such exchange of information on availability of spare parts for different items of equipment. A codified list could be developed for classifying like items of equipment so that in relation to the items of equipment so listed, inventories of available spare parts could be prepared at least to cover the high value items. Such items may not exceed 200 to 300 numbers of each make and model of machine. Periodical publication and circulation of such lists would be of great value and benefit to all concerned.

6.6.3 *Benefits*

The method of approach as defined above, would be of greatest benefit to all major users of equipment in the country in times of emergency, when sudden embargoes get imposed on import of spare parts from abroad. Such emergencies have arisen three times in the past decade. If there is a clear record of information indicating the names of the owners of given makes and models of machines in the country, as also the details of available items of spare parts in stock with them relative to those machines, emergent requirements of some items of spare parts of some of the users of equipment could be met with by mutual transfer of such required items from one project/organisation to others and vice-versa. The consequence of such handicaps and the resultant impact of such emergency on production in various fields or on the overall economy in various sectors could be fairly minimised by this process.

6.7 **Coordination in Developing Interchangeability of Parts Relative to Different Makes of Machines.**

6.7.1 *Commonality of parts*

As is well known, most of the original equipment manufacturers keep buying a substantial portion of their requirements of parts, components and assemblies from different primary manufacturers of such items. With the exception of a few principal manufacturers of equipment, assemblies like diesel engines, transmissions, hydraulic-system components, brake-system components, air system components, axles and differentials, fuel injection equipment, are purchased from some of the known and reputed makers of the same. Further more, certain items of spare parts like bearings of different types, gaskets, seals and filters and spare parts of diesel engines are also purchased from similar primary manufacturers. Hence, there is good deal of commonality by way of identity of spare parts amongst various makes, models of machines in different categories. However, the original equipment manufacturers choose to identify most of the items of spare parts of interchangeable nature by individual makers' spare parts numbers in their parts catalogues. A common user may not, therefore, ordinarily become familiar with such commonality in the identity of parts amongst different machines. Accordingly, if the user of equipment goes by individual makers' Part Numbers, he may occasionally rush forward to procure on emergency basis certain items of spare parts for a particular make and model of machine in a given category even though identical parts may be in stock with him for a different make, model and category of machine. Further more, the ignorance would lead to unnecessary downtime for the machine under repairs and consequently, there would be loss of production on the job.

6.7.2 *Attempts to Develop Such Commonality Lists at Present*

6.7.2.1 *By TECEDA*

The Tractor and Earthmoving Construction Equipment Distributors' Association (TECED Association) has recently taken some steps in this direction. They have published a Directory of Spare Parts of indigenous origin which indicates such interchangeability of indigenous spare parts relative to machines of different models in various categories but of the same make. Interchangeability of parts amongst different makes of machines has, however, not been established since the corresponding primary manufacturers' Part Numbers have not been identified therein. Hence, it would be more for the users of equipment to inter-relate the commonality and interchangeability of parts of different makes of machines.

6.7.2.2 *By users*

In respect of imported items of spare parts also an attempt has been made by some of the users of equipment to prepare interchangeability lists. This, however, is limited to a very few major users of such equipment.

6.7.2.3 *By private sector*

In the private sector also, one of the agent/distributor in India of primary manufacturers abroad, has prepared lists of interchangeable parts. He has, however, not disseminated the information to users of equipment in the country, except when business deals involving sale of parts by him to certain users had to be finalised.

6.7.3 *Developing Lists of Commonality*

To avoid such eventualities as explained at para 6.7.1 above, it becomes necessary that the equipment owners adopt a system whereby they may identify the main components, assemblies, and certain items of spare parts like bearings, seals, gaskets, filters etc., by the primary manufacturers part numbers. Through such an exercise, the equipment owner would ultimately develop lists of parts which would be common for use on most of the machines comprising the fleet of equipment working with him. Such identification of parts by primary manufacturers part numbers and the knowledge of certain common components and assemblies relative to machines working with him, would enable him to gainfully use such parts for expeditious repairs to machines on the one hand and for overall scaling of inventory of such common items of spare parts and assemblies so that minimum investment is made in purchase and stocking of such parts.

6.7.3.1 *By users*

The exercise of preparation of interchangeability lists on part of individual users could be facilitated if the primary manufacturers part number is recorded on the Bin Card, or the Cards in the Cardex System relative to each item of spare part in stock. To the extent possible, storage of such parts should also be so organised and arranged that such common parts are available in a given location inside the warehouse/stores.

6.7.3.2 *By original equipment manufacturers*

Such catalogues of spare parts indicating the interchangeability aspects being normally priced publications, it may perhaps be a good idea for the original equipment manufacturers in the country to make a joint effort in publishing lists of interchangeable parts for the benefit of the common user of such equipment. These could be priced publications. The least to be expected would be that the original equipment manufacturers in the country should identify the items of spare parts common to different models of equipment of the same make manufactured by them, or in respect of items like bearings, seals, gaskets and filters and indicate the identity of particular items common to machines of different makes and models manufactured by them.

6.7.3.3 *Coordinating cell to develop Master Lists*

If such lists of common and interchangeable parts prepared by the individual projects/organizations using earthmoving machines and other construction plant and equipment, and are passed on to a Central Coordinating Agency or Cell, the latter can consolidate the information in a more appropriate manner and prepare Master Lists of interchangeable parts for the benefit of all users of such equipment in the country.

In the U.S.A., the primary manufacturers of some items of spare parts like bearings, seals, gaskets and filters etc., have published Master Catalogues indicating relative to each particular size and type of their product, the identity by make and model of the machines on which it would fit. The proposed Coordinating Cell should be well equipped with such Master Catalogues of primary manufacturers so that it is easier to prepare Master Lists of interchangeable parts relative to equipment working in the country.

6.7.3.4 *Coordination between manufacturers and the coordinating cell*

The manufacturers of equipment in the country have also to be made partners in this work and there should be close coordination between the proposed Coordinating Cell and the manufacturers of equipment in the country in this respect.

6.8 **Coordination in the Matter of Indigenous Manufacure of Spare Parts**

6.8.1 *Manufacture of Parts by Equipment Owners*

Most of the major equipment owners who organise the maintenance and repair facilities on 'self-maintenance' basis, meet their urgent requirements of spare parts of not too complex a nature by design and metallurgical composition, by manufacturing the parts in their own Workshops. Some of them have a very scientific approach to the problem, in so much so, that they prepare working drawings relative to individual items to be manufactured, make a clear analysis of the metallurgical composition of the parts to be manufactured, and then manufacture the required parts. The performance of such standard parts is very satisfactory while in use on machines and most often, it not only matches the performance of the original part supplied by the manufacturers abroad, but occassionally excells the performance in terms of ageing quality.

6.8.2 *Manufacture Through Private Industry*

In some cases, where the available manufacturing facilities of the equipment owner do not accommodate such production/manufacturing programmes, assistance is sought from private manufacturers/ancillary industry to develop such parts. Their quality in use is proven after proper tests and trials over given periods of time.

6.8.3 *Work of Coordinating Cell to Disseminate the Information*

In order to promote indigenous manufacture of spare parts as a process of progressive development in the country, it is necessary that the users of equipment should propagate the information relating to parts manufactured by them, or those that have been manufactured on their behalf by outside agencies and found to be of proper standard. This could be done by passing on the information periodically once every quarter, to the Coordinating Cell. The Coordinating Cell in turn, would circulate this information for the benefit of users of equipment in the country through periodical bulletins once every quarter.

6.8.4 *Indigenous Manufacture of Spare Parts—Proposal based on Contemporary Thinking for Accelerating Import Substitution*

Even though it is to be generally admitted that non-availability of drawings for spare parts from the suppliers of equipment or the original equipment manufacturers, is the main handicap to the promotion of indigenous manufacture of spare parts to the required extent; it is realised that in some cases, the technical specifications can be drawn and working drawings prepared in respect of some items of spare parts. However, in view of the small size of orders for spare parts from individual equipment users in relation to the few items which can be so developed for manufacture, the spare parts manufacturing industry has not shown sufficient interest in taking up manufacture of such parts.

This matter has been under discussion in the past amongst CW&PC, DGTD, DGS&D and the suppliers of equipment and some progress has been made in this direction. Further proposals have now arisen based on contemporary thinking in this respect in the DGTD and the Department of Industrial Development. The main outline of the proposal discussed in one of the recent meetings is as follows:—

Proposal

It is felt, properly co-ordinated and organised, a significant portion of maintenance spares for imported equipment which has hitherto been imported can be produced locally to meet the needs of various Indian Industries and Defence Establishments. It is desirable that a Central Agency should be responsible for the overall assessment of spare parts requirements and programming priorities for the technical work necessary for taking up local manufacture of the items. The main functions of such a Centralised agency would be:—

(a) Commissioning of the Study for inventory or requirements and following up the progress of the same including arrranging for user industries providing necessary information and facilities to the agency responsible for undertaking the study;

(b) Ensuring that wide publicity is given to the requirements of spare once the above study is completed with a view to entrusting existing manufacturers with requisite facilities in the manufacture of the items;

(c) Programming the priorities for import substitution of spare parts and placing of orders on the selected consultant/engineering organisation for studies in this regard;

(d) Arranging for constant liaison with user industries at all stages of the development of indigenous designs and evaluation of the manufacturing technology;

(e) Ensuring that there is adequate feed back information to the coordination agency and through it to the consultant/engineering organisation responsible for developing indigenous designs and manufacturing technology. Such feed back information would consists of drawings of spare parts where available, samples or prototypes, specifications, user experience etc. It may be mentioned that furnishing of such information by user industries to the coordination agency is vital to ensure that the designs and technology involved meet user requirements adequately. If necessary, the furnishing of such feed back information must be enforced by proper regulatory measures such as requiring transmittal of the information to the Committee whenever applications for imports are made.

In order to be effective, such a Coordinating Agency must be a High Level Interministerial Committee so as to invest the decisions of the Committee with a measure of finality.

Since the universe of usage of imported spares is very large, it would be desirable to concentrate on certain areas where the quanta of imported spares usage is high. It is felt that for the present, the following areas be studied:

Construction and Mining Equipment, Steel Industry.

Fertiliser Industry.

Power generation and transmission.

For the proposals as above to be given a complete shape, at least in relation to Construction and Mining Equipment, the envisaged functions could be assigned to the proposed Equipment Planning Committee and the Coordination Cell of the C.W.&P.C.

6.9. Management and Control of Equipment

6.9.1 *Need for exchange of Ideas*

With a view to introducing methods of improvement in construction methods and techniques and in the matter of proper utilisation of equipment on the job under different conditions, it is necessary to have exchange of information regarding management and control of equipment enforced by different major users of equipment in the country. As at present, there is great divergence in the standard of utilisation of equipment by different users. Details given in Chapter 2 are clearly indicative of the high efficiency in utilisation of equipment on part of some of the projects while in most of the other cases, the average utilisation figures are very low—in some cases even 5% to 7% annually. There could certainly be great scope for critical examination of the main causes contributing towards such underutilisation of equipment with some of the users. Specially when very high degree of efficiency in utilisation of equipment has been achieved by some. The scope of improvement being certainly there, those who have not succeeded in achieving the required degree of utilisation of equipment, can learn a lot from the others who have performed better in this direction. The administrative control, the organisational set up, the maintenance and repair procedures adopted, the facilities created for proper maintenance and repair of equipment etc., etc., by those few with whom equipment have given good performance can be subjects of education for the others.

6.9.2 *Disseminating Information*

The Coordinating agency should keep examining necessary details in this respect with all users of equipment in the country; and disseminate the information as such to all users of equipment in the country. Illustrative examples worked out on basis of economy entailed by small investments, in establishment costs for proper administrative control, maintenance procedures and repair facilities, should be worked out, based on actual data obtained from particular projects, and the results communicated to all concerned.

In fact, certain procedures should be laid down for collection of such data by the project authorities or users or equipment, in the course of use of machines on their jobs. Such compilation of data should be available to prospective users of similar equipment on new schemes, or on other continuing projects. Such data can be reflected in 'Completion Reports' of completed projects, or this can be circulated in periodical publications to be issued by the continuing projects. A Central Coordinating Agency can liaison in this matter in condensing the information from all such publications and preparing 'Guide Hand Books', for the benefit of the other users of similar equipment in the country.

The information to be included in completion reports of projects or in periodical publications, would high light the results of 'Time and Methods Studies' carried out by the individual users and would relate elements of cost to time and production. Favourable, or unfavourable results pointed out by the data so compiled is of great value to the project authorities, or users of equipment in localising defects/difficulties that might be created by changing the methods of work, or wherever necessary, the types and makes of machines as well as the personnel.

Operations related to time, productivity or methods, study, are listed below as a partial guide for all concerned:—

(1) Detailed breakdown of cycle time for cableways, cranes, batching and mixing plants, concrete transfer cars, concrete carriers—haul trucks or trains, power shovels, draglines, motorised scrapers, tractors/dozers, dump trucks, spreading equipment on embankments, compaction equipment, round cycles in tunnel and shafts etc., etc.

(2) Production studies are advisable for rock drill, power shovel, or dragline loading (volumes measured by crosssections or computed quantities, number of truck loads etc.), hydraulic sluicing, blasting results etc.

(3) Efficiency of equipment should be checked to determine if it meets manufacturers' rated capacities, or if it is accomplishing the performance fully for which it is provided. This would apply somewhat generally, but observations should be made with respect to pumps, crushers, rod mills, sand classifiers, conveyors etc.

6.9.3 *Organising Seminars*

There should be annual Conferences/Seminars for exchange of views on technical matters relating to construction plant and equipment, so that the benefits of organised methods of management and control of equipment could be shared by all with the ultimate objective of optimum utilisation of equipment, maximum production thereby and least cost in work.

6.9.4 *Analysing Problems Faced by Users for Discussion*

Any procedural/policy problems relative to procurement of equipment and spare parts which would otherwise relate to DGS&D and the CCI&E or the individual purchase organisations of different States, could also be discussed in a joint forum and practical solutions suggested and recommended for implementation by the Departments concerned or the Government.

6.10 Conclusion

In conclusion, it may be indicated that it is considered most essential to set up a Central Coordinating Agency and the Equipment Planning Committee, if the overall objectives as defined at paras 6.2 and 6.3 have to be properly realised and fulfilled effectively. A separate whole-time working Coordination Cell alone will be in a position to make it possible for the envisaged benefits to be properly derived for the common benefit of all users of equipment in the country. The size of the envisaged organisation would be equivalent to a full-fledged Directorate, if the pattern of work in the CW&PC is to furnish any guide line in this respect. A half hearted approach in this direction will be utterly meaningless and ineffective.

The importance of the Equipment Planning Committee will be manifest from the benefits on the economic front that could be derived through the good counsel and advice which are rendered to all users of equipment in technical matters relating to equipment and in facilitating a better and more reasonable framework of Government policies and procedures in the matter of procurement of equipment and spare parts so as to minimise downtime of equipment and consequently achieving optimum utilisation thereof.

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6.11 Summary of Observations and Recommendations

The equipment operatives gain limited amount of experience on their jobs in the matter of basic planning for equipment, establishing proper methods of work for optimum utilisation of equipment, resources provisioning—specially materials and spare parts for equipment, standardisation, indigenous manufacture of spare parts, training programmes, assessment of maintenance and repair costs of equipment etc., etc., Unless the users mutually share their expenrience in these matters, it is difficult for them individually, or collectively, to introduce methods of improvement in equipment management. In special reference to resources provisioning, individual users have to approach a Central/State Authority for revision/amendment of policies and procedures so that delay in procurement could be avoided.

With the progressive development of indigenous equipment in the country, the individual users' requirements cannot be suitably met with unless the authority controlling/licensing the individual manufacturer takes an integrated view of the job requirements of a number of users collectively—those who may use such equipment commonly.

The individual users cannot assess their own efficiency in management of equipment from stand point of economy in operations, unless they compare notes on this account with other users and judge for themselves if any cost saving devices could be introduced.

For these aspects to be functionally covered, it is necessary to establish an agency for coordination amongst users of equipment and on their behalf (collectively) with these who are directly responsible for formulation of policies and procedures for equipment and resources provisioning. Such coordination agencies do exist in individual sectors, but the main agency to coordinate with these coordinating agencies is nonexistent.

Investment in equipment is rendered partially unproductive when the equipment users cannot make gainful use of some of the available equipment. On the other hand some other needy users of such equipment, initiate action for procurement of additional equipment to meet their schedules of production. Such situations arise in individual States where a number of users of such equipment exist or in particular sectors having a number of projects under their control. For the surplus equipment to be rehabilitated on work expeditiously, a coordinating agency alone can render necessary help.

For this to be achieved the following recommendations are made:—

1. A standing Committee on Equipment Planning be constituted under the aegis of the Ministry of Irrigation and Power in lieu of the present Standing Committee of Experts on Standardisation of Earthmoving Machines. The functions to be assigned to the Committee are as follows:—

(i) Examination and assessment of requirement of equipment on new projects in the Irrigation and Power Sector;

(ii) Prescribing norms/work standard units etc., for work with equipment;

(iii) Systems analysis for economy in work with equipment in projects;

(iv) Advice regarding manpower, their training, maintenance engineering, inventory control methods, record keeping etc., on unified pattern basis by all Irrigation and Power Projects.

(v) Advice to all users of equipment (when called for), in different sectors, including Public Sector, on (i) (ii) and (iii) above.

(vi) Vetting of demands for additional equipment with due considerations to the existing equipment available with the indenting departments;

(vii) Trends in development of equipment and methods and techniques of their use abroad—updating of information for gainful use.

(viii) Liaison with the DGTD and Industrial Development Department regarding:—

(a) New items of construction plant and equipment to be undertaken for manufacture;

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(b) Review of production of indigenous equipment—production levels, demands, quality of product, performance of equipment—in specific context of reports from users, and the consequent recommendations for improvement, planning for indigenous manufacture of spare parts etc., and standardization of equipment.

(ix) Liaison with the DGS&D and CCI&E in the matter of:—

(a) Rate Contracts for indigenously produced components and spare parts for earthmoving machines, diesel engines etc.,

(b) Rate Contracts for imported items of spare parts—the technical aspects mainly in relation to (a) and (b) of (ix).

(c) Framing policies, procedures and rules for procurement of equipment and spare parts as well as import thereof.

(x) Standardisation of equipment.

The Committee will be comprised of members (senior officers) nominated by major users of equipment namely, the NMDC, the NCDC, Irrigation and Power projects, DGBR/Engineer-in-Chief's Branch of Army Headquarters, the Ministry of Transport and any other Central/State Government Department. Only three Members may be nominated from these departments at one time—one each from mining sector, Irrigation and Power Sector and the rest. The fourth Member will be (on permanent basis) the senior officer controlling the Plant Planning Directorate in CW&PC.

The Chairman of the Committee will be an Engineer of the rank of a Member in CW&PC/Joint Secretary in the Central Government.

2. A Co-ordination Cell/Agency be created—equivalent of a fulfledged Directorate of CW&PC, at the Centre—under the aegis of one of the major sectors using the largest fleet of equipment. The functions to be assigned to the Agency/Cell are as follows:—

(i) Basic planning for equipment—assessment of requirement based on practical norms of production, selective choice of equipment, relative to field application or work where it will be used, operation, maintenance and repair of equipment, inventory control of spare parts etc., etc.,

(ii) Utilisation of surplus equipment by timely disposal/rehabilitation/transfer to other needy users to save additional investment on new equipment, simultaneously utilising the blocked up capital already invested on such equipment.

(iii) Determination of availability of spare parts for like items of equipment with various users in the country, to provide ready availability of some of the vital parts which being available as unused at some locations, may serve to commission some idle equipment elsewhere.

(iv) Dissemination of information regarding interchangeability of parts relative to different makes and models of machines, as initially compiled by the individual users of equipment in various sectors.

(v) Indigenous manufacture of spare parts—facilities and capability of different organisations in this respect and the outside sources and private sector relating thereto.

(vi) Liaison with the Industrial Development Department of Ministry of Industrial Devlopment and the Directorate General of Technical Development in matters relating to clearance for import of parts and equipment that are not manufactured in the country.

(vii) To lay out the framework of formalised training programmes.

(viii) Updating and revision of norms relative to production by different items of equipment under different situations and their utilisation.

(ix) Collection of data on repair costs of equipment.

(x) Standardisation of equipment through collection of performance data.

(xi) Methods of improvement in management and control of equipment.

(xii) Evolving a unified pattern for record keeping in relation to performance of equipment and cost accounting.

3. For convenience of inter-departmental and intra-departmental coordination in matters relating to equipment and specially that relating to exchange of information on availability of spare parts for different items of equipment, a codified list should be developed for classifying like items of equipment for preparation of inventories of spare parts—at least for high value items.

4. To provide a proper forum for exchange of views on important matters relating to equipment, selection, operation, maintenance and utilisation, annual Equipment Seminars should be organised.

To keep abreast with the trends in development of equipment abroad, methods of training, improvements in methods and techniques of maintenance and repairs, inventory control of spare parts and to establish an effective communication with the suppliers/dealers of equipment for problems faced by the users in the matter of after-sales-service, disposal/rehabilitation of surplus spare parts etc., the Coordination Cell and the Equipment Planning Committee, may associate a bonafide representative of major association representing such organisations. Similar assistance may be listed from amongst the leading manufacturers of equipment.

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CHAPTER 7.

TRAINING OF OPERATORS AND MECHANICS—REVIEW OF ADEQUACY OF PRESENT ARRANGEMENTS ETC.

7.1 Introduction

With the increasing complexity in handling construction jobs, the need for continuing education, at all levels in the construction industry, is getting more evident. The equipment manager is being progressively called upon to work with sophisticated, new and improved equipment costing hundreds of thousands of Rupees—equipment too costly to be entrusted to the inexperienced. It is his effort to so organise the operations with equipment that optimum utilisation, maximum production and least down-time of equipment can be achieved for most economic results in the end cost of production. For this to happen, the basic requirement is a well-trained equipment organisation which shall adopt a comprehensive system to performing the service maintenance and repair of machines with the help of suitably trained persons and proper facilities.

The economy of equipment operation will depend to a large extent on the efficiency of the equipment organisation as a whole.

7.2 Operators and Mechanics Training

The key members of the equipment organisation are the operators who run the machine and the mechanics who provide the supporting line to back up operations. The two have necessarily to work as a team.

During the early days of mechanization, new operators could usually be developed under an apprenticeship programme. Under the present conditions with a larger ratio of machines to manpower and other industries competing for skilled operators, it has become necessary to initiate formalised operator training on an accelerated scale.

The training programme has furthermore to keep pace with the technological developments in the field of construction equipment. To accomplish this, specially the repair and service crew have necessarily to have an insight into the construction features and processes of dismantling and reassembling of components, assemblies and sub-assemblies used on machines.

One of the easier ways which is generally adopted for training of such personnel (on the job) is in-service-training. Such in-service-training and education no doubt, stands in good stead to those who possess basically the fundamental skills necessary to the trades of operation, maintenance and repair. However, with the accelerated pace of increase in population of equipment and simultaneous developmental activity arising from undertaking of new schemes employing large size fleets of equipment, it becomes necessary to provide contingents of trained personnel for operation and repair of equipment. Such personnel who have no past experience of these trades, can be trained through formalised training programmes only.

7.2.1 *Benefits of Training*

The motivation for formalised training to different categories of staff results from rather disturbing position of low utilisation of equipment on different jobs in various sectors in the country. As already indicated earlier, the average utilisation of equipment in the country is 40% to 50%. The value of major items of construction plant and equipment in use in the country being estimated at Rs. 3500 million, equipment worth Rs. 1750 million is unproductive. Such equipment being, at an average, capable of producing goods and materials worth 30% of its cost every year (it can some times be 40% of the cost every year in exceptional cases), the value of production lost each year will be of the order of Rs. 520 million approximately. Perhaps, by a judicious planning of equipment use on the job, quicker repair and timely detection of defects by careful operation which are possible through planned training, one could bring around 15 to 20% of the unutilised equipment to active production. This would mean an additional production of Rs. 40 million to Rs. 52 million every year.

Briefly speaking, what is to be aimed at is 'Work improvement'. Certain formal methods, if introduced in the direction of training and education will better ensure a reasonable productivity for the wages and other costs incurred on jobs where intensive mechanisation is involved.

It has happened most often that engineers and superintendents dismiss the whole concept of methods improvement in the belief that they are accomplishing the same results without the bother of any organised or formal techniques. By so doing, two important concepts are missed; the first is that, in following a formal procedural system, there is less opportunity to ignore or overlook important points; secondly, in bringing operation away from the routine of the job or hustle and bustle of the job, it is possible to be far more analytical and thoughtful.

It is, therefore, necessary to formulate the training programmes with certain objectives in view.

7.2.2 *Objectives of Training Operators and Mechanics*

7.2.2.1 *Operators' training*

To understand clearly,

1. Performance and capabilities of the equipment (importance of avoiding overloading, overspeeding and other abuses).
2. Functional value of equipment as a unit and as a part of combination of machines on particular job applications.
3. A thorough study of prescribed recommendations of the manufacturer in relation to particular items of equipment.
4. Lubrication requirements.
5. Preventive maintenance procedures.
6. Operating techniques.
7. Local job conditions and problems affecting use of given items of equipment.
8. Safety of operations for self and others within the work environments.
9. Care during periods of inactivity.
10. Close coordination with Mechanics.

Mechanics' training

1. To develop a knowledge of functional aspects of the machine as a whole, the components, assemblies and parts thereof, and the systems—hydraulic system, cooling system, lubricating system, brake system etc., integral parts of the machine.
2. To understand the construction of individual components, assemblies and parts.
3. To develop knowledge of repair, servicing and maintenance techniques.
4. To understand in relation to given items of equipment the preventive maintenance work, including "Trouble shooting" and adjustments.
5. To understand the inspection techniques for precise assessment of functional condition of components and parts and to create records of observations, regarding extent of wear and tear, types of defects, causes of defects etc.
6. A thorough study of prescribed recommendations of the manufacturer in relation to particular items of equipment regarding process of disassembling and resassembling parts, components and assemblies, as well as the machine as a whole. In brief, the shop service instructions in the matter of repair of various components and assemblies and the machine.
7. Lubrication requirement.
8. Close coordination with operators.
9. To develop a competence in the matter of reference to shop Service Manuals, Spare Parts Catalogues and Service Bulletins.

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10. To acquire competence in standards of limits, fits and tolerances in process of fitment and assembly of parts.
11. Use of special tools, jigs and fixtures and other facilities incidental to repair work.
12. Safety in handling, servicing and repair work.

Many of the objectives listed above, will seem so simple ultimately that a sophisticated person will often pass them by, some may even consider the preposition of training some categories of persons for accomplishment of some of these objects even an insult to a reasonable man's intelligence. However, if work improvement methods have any meaningful significance in context of the improvement in management of equipment, such basic details seem necessary to be defined.

7.3 Existing Training Programme

7.3.1 *Formalised training at the Training Centres*

Keeping these objectives in view, the first Construction Plant & Machinery Committee had recommended a certain form of formalised training of operators and mechanics to be introduced under the aegis of the Ministry of Irrigation and Power/Central Water & Power Commission. Accordingly, four Technical Training Centres were established, one each at Nagarjunasagar Dam Project in Andhra Pradesh, Kota in Rajasthan, Kakrapar in Gujarat and Nangal in Punjab. This programme of training was initiated in the year 1955-56.

The Technical Training Centre at Kakrapar was closed in the year 1970 and as at present, only three Technical Training Centres are in operation.

A large number of users of equipment have availed themselves of the training facilities provided in these Technical Training Centres of the CW&PC. Simultaneously with the growing need of operators and mechanics, for work with machines on new schemes in different sectors, the users of equipment have organised suitable training facilities under their own establishments. In some of the organisations, such facilities are being created to meet the mandatory requirements of the statute relative to particular industries.

Yet, the only organised formal training imparted at present, is that in the Technical Training Centres organised by the CW&PC. Details in this respect are as follows:—

The training course, as conducted by these Training Centres, covers broadly the operation, maintenance and repairs of major items of earthmoving machines—Power shovels, and cranes, dumpers, motorised scrappers, towed scrappers, motor graders, crawler tractors etc. etc.

The trainees admitted to these training courses generally have basic academic qualifications of Matriculation or Higher Secondary Examination. In some cases, Inter Science students and Science Graduates and Mechanical Engineering/Electrical Engineering Diploma holders also come up for this training. Generally, however, candidates having higher academic qualifications are few, since quite often, the resultant skill, proficiency and knowledge attained by them at the end of this training does not secure them suitable jobs. Their market rating is also low from standpoint of wages they can earn or places/positions they can attain. Hence, there is very little incentive for the trainees who may seek admission to the training courses being run through the Technical Training Centres of the C.W.&P.C.

The number of persons, who qualified themselves as operators/mechanics as a result of their training in the Technical Training Centres of the CW&PC upto the end of last year—1971, is 2013.

Information has also been compiled by the Committee regarding number of trainees which successfully passed each year through the existing three Technical Training Centres at present run under the CW&PC. This is given at Appendix 7.1.

It may be seen from this Appendix that the number of trainees passing through the Technical Training Centres has varied from 25 to 70 per year. This, however, does not correspond to the rate of growth of equipment otherwise reflected in Appendix 1.11. Evidently, either some surplus trained operators and mechanics were available in the open market to meet the additional requirements for the equipment added year after year; or the purchasers of equipment anticipating additional purchase of equipment, had taken earlier steps to train the required number of persons at their own project sites. Yet another possibility is that some old employees in the "Helpers" class would have been put on the machines and trained as operators. The third possibility (preceding) cannot be discounted when the figures of low utilisation of equipment of that period of origin gets substantiated by the information received from the users of equipment.

Apparently, therefore, the equipment owning authorities do resort to training of operators and mechanics at the projects. This of course, is the process of "learning while on the job".

How satisfactory is this process of training and what is the degree of skill acquired by the persons so trained, is not evaluated properly. Such trained hands are placed in junior most positions and take their turn to be better placed in due course of time in their service career on a given project. This no doubt, provides a convenient and easy means for fulfilling the requirements of operating and servicing personnel; but in this process, what expenditure is incurred by way of losing the valuable production time of machines, and through greater down-time due to unsatisfactory repairs done by the mechanics under training, has never been evaluated. This cannot in any case, be termed as 'satisfactory arrangement' as the cumulative cost of such training would be disproportionately higher than the cost otherwise involved under a formal training programme.

In the Mining Sector, including N.M.D.C. N.C.D.C., Neyveli Lignite Corporation and Hindustan Steel, the training at project sites is supplemented by class-room lectures. However, these lectures do not cover the basic fundamentals of the subject in so comprehensive a manner as is done in the Technical Training Centres of the C.W.&P.C. The main advantage of the training programmes as followed in the Mining Sector, according to the authorities concerned, is that the persons so trained are better acquainted with the actual work to be done by them and after training, they prove to be more useful. The training so given being on the particular machines which are in use (and these being more recent models of equipment in different categories), is considered more appropriate from standpoint of the equipment owners' requirements. At the C.W.&P.C. Technical Training Centres, trained persons receive such training on much older and obsolete models of equipment.

Here again, no evaluation has been made about the cost of such training in terms of loss in production, down-time of equipment etc., etc.

7.3.2 *Training Education given by Manufacturers and Dealers of Equipment*

Besides the formalised training imparted by the Technical Training Centres of the CW&PC and the users' organisations for such education to be given at project sites, the manufacturers and dealers of equipment also have suitable facilities for imparting such training to the personnel of the purchaser organisations besides those for their own service staff. Most often, the operators' training is imparted at the site of the work where the machines are in use. The operators are made familiar with the proper techniques of operation of individual machines sold by the manufacturers/dealers. The maintenance programme for those machines is also clearly defined and the users of equipment are made fully conversant about their details. These are, however, short-term courses; and these can be useful to only such class of persons as have previous knowledge and experience of operating or maintaining similar machines of other makes and models.

Formalised training is also imparted at the manufacturers'/dealers' own premises in training schools. Most often, the training courses cover the mechanics' trade in relation to the particular makes and models of machines manufactured/marketted by them. With one of the dealers of imported equipment in the country, such training courses for mechanics extend over periods upto two years. Most of the time the personnel of the service organisation of the dealer himself are trained through these training schools. Such trained service hands of the dealer do conduct courses at sites of work where identical machines are in use and in turn train the users' staff. The intensity of such programme of training by the trained staff of the dealers has, however, comparatively reduced in the recent past due to reduced quantum of imports of equipment from abroad in the country.

The dealers of equipment also accept persons nominated by the users of equipment for training in dealers' training school. If such training is of long durations, the sponsoring authority has to bear the expense of training to some extent. For short-term courses which is generally in the nature of refresher courses, no fees are charged.

The main manufacturer of earthmoving machines in the country, namely, M/s. Bharat Earth Movers Ltd. have organised a training institute in Kolar Gold Field area contiguous to the equipment manufacturing plant of the company. The training programme, however, has not so far received the required amount of impetus in training nominees of the users of their equipment, though plans are afoot to augment the programme suitably.

A note indicating details of training imparted by M/s. BEML in relation to equipment manufactured and sold by them is at Appendix 7.2.

7.4 Need for Improvisation of the Training Methods, Techniques and Facilities

With the rapidly increasing industrial development activity specially in the mining and construction industries, the pace of mechanisation has also to be considerably accelerated. The growth of equipment in the country having been however, partially handicapped during the transition period when curbs have been laid on imports and the indigenous manufacture has not caught pace with the requirement to the required extent, development in this direction has been partially retarded. All the same, if production programme and development activities have to keep pace with the envisaged rate of economic growth in the country, it should be reasonably expected that provision of equipment would soon keep pace with the requirement. Accordingly, there will be a fairly great demand on the training organisations for providing trained personnel for operation, maintenance and repair of additional new equipment.

The Technical Training Centres under the CW&PC are unfortunately, equipped with machines and facilities which were introduced and established in the 50's or early 60's, while the present day equipment is far different in construction designs and features. Hence, to meet the basic requirement of a formalised training programme in a satisfactory manner, it is only essential that the equipment of more recent origin should be provided for training of operators, and similarly, the facilities for training of mechanics should be so improved that a trainee-mechanic gets fully conversant with the components, assemblies and sub-assemblies generally used on such equipment of recent origin.

Furthermore, the present scheme of training, as adopted by the Technical Training Centres of the CW&PC, provides for an integrated course of one year's duration for operators/mechanics. Such training is given in relation to above six categories of machines namely, excavators, dumpers, crawler tractors, scrappers towed and motorised, graders and cranes. The operators undergo operational training amounting to a total of 125 machine-operation-hours, while the machanics' trade is covered through periodical repairs to equipment used for training in operation besides repair and overhaul of a very few assemblies/components of machines. Through this process, it is difficult to expect of the trainees to achieve the required degree of skill in mastering operation of individual categories of machines or to attain the required skill in repair to equipment, assemblies and components etc.

The equipment owners are at present more keen to have specialised operators—individually for different categories of machines, mainly due to the fact that large-sized machines in each category, which are very costly, are being put to use in construction industry and mining industry. Hence, it becomes necessary to lay greater emphasis on specialised training of operators on individual categories of machines according to the needs of the equipment owner, rather than producing universal operators. It would be possible to produce specialised operators in comparatively short-term courses of 14 to 16 weeks. The operator-trainees can also learn properly the maintenance work of the machines they will operate.

The mechanics' courses would, however, be of longer duration—extending from 40 to 60 weeks, depending upon the particular assemblies/components on which the trainee would choose/get nominated to work.

7.5 Formulation of Training Programme for Future.

7.5.1 *Underlying Considerations*

The underlying considerations which would generally guide formulation of proposals for any training programme are as follows:—

1. A means of determining the number of men to be trained.
2. A means of determining how, when and where training is to ge given.
3. Selecting qualified men for training.
4. Determining standards of performance and measuring performances of trainees against standard of performance.

No doubt, another important consideration which should also arise in this context is: "Job progression schedule, showing personnel requirement and classification thereof with wages and relating these to a training schedule." However, since this is a matter which would concern individually the industries or equipment users who otherwise admit the need for formalised training programmes, this has not been gone into in detail. Basically, the classification of personnel and their wages etc., are so widely different from one user of equipment to another in different sectors that it is difficult to come to an integrated thinking for uniformity purposes in this respect.

In what follows, the Committee have covered the other four considerations as listed above.

7.5.2 *Number of Trainees to be Trained*

It may be seen from the details given in para 1.7.2. in Chapter I. that during the period 1960 to 1969, about 1100 Nos. of machines, at an average, were added annually to the fleets of equipment in use in the country in various sectors. This figure may also serve to represent the pattern of future additions of equipment in various fields, as this is also commensurate with the programme of indigenous manufacture of major items of equipment in the country. Considering that about 2/3rds quantity of these additions would form replacement of the existing items of equipment for the remaining 350 Nos. approximately, newly trained operators and mechanics would be required by the users of equipment. Taking two shifts operation of machines, the number of operators required would be 700, while the number of mechanics required would be 350. If it is assumed that about 50% of this requirement may be met with by other sources, and through users own resources on the job, we would be left with the requirement of 350 operators and 175 mechanics annually for training through Training Centres. If three Technical Training Centres producing specialised operators, are managed properly, they may produce 120 Nos. operators and 60 trained mechanics per Centre,each year. This will further be reduced to producing 30 trained operators per session of 3 months per Centre, while in respect of mechanics' trade where one year's course may be involved for training mechanics, 60 trainees per Centre could be conveniently managed for training.

7.5.3 *Facilities*

Another factor to be considered in context of the training of the trainees is the equipment and facilities available for training, and the instructing skill. Lack of instructing skill or proper material and facilities or both, in imparting good instructions, may be most detrimental to the cause of the training and more so to the cause of efficient operation of equipment. In such a case, it might be better to go without a training programme. A poor presentation is worse than nothing at all and it only serves to antagonise the learner to the point where he loses all interest and thereby producing a negative result. It is, therefore, necessary to have a constant review not only of the programme, but of the instruction and facilities as well.

7.5.4. *Equipment*

The Technical Training Centres of the CW&PC are presently equipped with very old and obsolete models of equipment in different categories, which were initially arranged for by the US AID authorities under the Grant-in-Aid Programme for running a pilot scheme for such training. Even though in some of the Training Centres further additions were made in replacement of the old equipment, the newly added machines were also in no way representative of the latest models of equipment in the market and in use in various fields of application in different sectors.

The operational cost of the machines by operators is comparatively an insignificant part of the whole training programme, on such construction equipment and machinery. To train people on old, obsolete models of equipment, does not fit properly into this thinking, and accordingly, it may be difficult to expect that the trainees turned out by the Technical Training Centres can fit in properly on operation of new sophisticated equipment on various works involving intensive use of such machines.

Similar would be the position regarding training of Mechanics for maintenance, repair and overhaul of new machines of complex design. The technological advancements in the design of construction equipment necessitates continuing education in this field not only as a requirement for tomorrow, but to fulfil the need of the day and the hour. Undoubtedly, the efficiency of equipment utilisation and in effect, the efficiency of the entire equipment operation, can be increased through in-service training and education. The trainees turned out by the Training Centres have, therefore, to keep learning continually the individual machine's designs and operational controls, before they can be successful in operating and maintaining the machines in a proper manner and give the desired level of performance in the use of these machines. Basically, however, the trainees have to familiarise themselves with the design and construction features of these machines only in the Training Centres.

It is, therefore, very necessary that the facilities for training in the Technical Training Centres be so remodelled that these provide equipment in different categories of a more recent origin for operators' training. Similarly in relation to training of mechanics, a variety of latest models of components and assemblies, like diesel engines, transmission, torque-converters, final drives, track-group components of crawler tractors, hydraulic system, brake system etc., etc., are also provided.

7.5.5 *Nature of Training*

According to the present system of training, the Technical Training Centres produce 'Universal operators' who are conversant with the operation of crawler tractors, motor graders, motorised scrappers, dumpers, shovels and cranes etc. Perhaps, the needs of the individual projects/equipment owners would be more in terms of specialised operators, trained to operate particular types of equipment only. To appropriately meet such envisaged requirement of specialised operators, the Training Centres would have to be so equipped that comparatively larger number of machines of particular categories are provided at each Centre so that a number of trainees can be trained in operation of that category of machines simultaneously in a short duration. Further more, the Training Centres can have different categories of equipment e.g. at one Centre shovels, dumpers and graders, and at another crawler tractors, scrappers motorised and towed and a grader.

The duration of training specialised operators will be twelve weeks per category of machine. In case it is intended to train the same operator on more than one category of machines, the total time required would be commensurate with the number of categories of machines on which he is to be trained. This will be the choice of the trainees' sponsoring authority.

For mechanics' training, consistent with the objectives defined in para 7.2.2 the main consideration would be to make the trainee fully conversant with the process, procedure and technique of repair work on different assemblies, sub-assemblies and components of the machines. The items of diesel engines, transmission, brake system, hydraulic system etc. etc., being common to most of the equipment, the trained mechanics produced through such formalised training programmes would be able to handle the repair work of particular machines in any set up with a little of the supplemntary training on the job, which in any case, has to be provided to complete such training. The duration of the training may be for a period of 12 months.

Remodelling of facilities in the Training Centres in this fashion, of course, would necessitate a fair amount of additional investment for equipment and facilities etc.

7.5.6 *Selection of Trainees for Operators' Training and Mechanics' Training*

The importance of establishing a definite, rigid selection procedure for men entering training, cannot be over emphasised. Every person, recruited for such training, is a potential operation and maintenance foreman. Bearing in mind this perspective and the fact that a sizeable monetary investment is made in turning out each qualified trainee, the rigid selection programme is of good commonsense insurance. Further more, good selection means lower turnover costs, lower costs of training, better employee morale, more output.

It is necessary that I.T.I. qualified persons, or Diploma Holders in Mechanical Engineering, may be admitted to the envisaged training programmes. The cost of investment in such training will be duly repaid if the trainees can fully absorb the training; and this they can do only if they are basically familiar with the fundamentals of science, workshop practices, etc. This can be expected of the persons coming from Industrial Training Institutes and other Polytechnic Institutes who award Diploma in Mechanical Engineering.

The country has over 350 Industrial Training Institutes all over the States. It would not be difficult to attract at least one trainee from every I.T.I. on voluntary basis for such training and such candidates can be sponsored by the individual users of equipment.

If the users of equipment have certain persons with suitable experience in handling items of equipment on the job, they could also be sponsored for such training. The training in the T.T.C.s. would be well absorbed by them and they will turn out to be properly skilled in the trade in which they are trained.

7.5.7 *Location of Training Centres*

The 3 Training Centres being run by the CW&PC at present, are located at Nangal in Punjab, Kotah in Rajasthan and Nagarjunasagar Dam site in Andhra Pradesh. Looking to the concentration of equipment in different areas of works in the States and in the country, it may be better to relocate atleast two Training Centres one at Nangal and the other at Nagarjunasagar Dam, by shifting these two to Raipur in Madhya Pradesh and a suitable place in Mysore State. In so far as the Madhya Pradesh State is concerned, the Iron Ore Mines, the Coal Mines and the Irrigation and Power Projects in West Bengal, Orissa, Bihar, U.P. and M.P. and a part of Maharashtra contiguous to Madhya Pradesh State, more than amply justify the location of the training Centre in Madhya Pradesh State.

For the Training Centre in Mysore State, the requirements of Andhra Pradesh, Tamil Nadu, Kerala, Mysore and part of Maharashtra States could be catered to.

The Training Centre at Kotah in Rajasthan would cater to the requirements of trainees of Punjab, Himachal Pradesh, Rajasthan, J&K and Gujarat.

Even though certain benefits of training are evident if the training centre is located at a project-site, the general psychology of trainees, who would undertake such training, being a consideration of equal importance, it may be better to have the Training Centre located near a Rail Head and in close proximity to some of the I.T.Is.

7.6. Management

7.6.1 *Training, a Joint Venture*

Even though the Technical Training Centres were initially established under the administrative control of the Ministry of Irrigation and Power and under the aegis of CW&PC, looking to the need of the hour, such training is necessary for persons employed on working similar machines in the following major sectors:—

	Value of equipment (Rupees Crores)
I. & P. Sector N.P.C.C. Ministry of Transport	140
Border Roads	20
N.M.D.C.	15
N.C.D.C.	30
H.S.L.	20
Neyveli Lignite Corporation	23

The value of equipment operating with these sectors as per statistics compiled by the Committee are shown above, against each. The Irrigation and Power Sector is seen to own 50% of the total value of such equipment in the country (major items of earthmoving machines). The Irrigation and Power Sector may still continue to own the responsibility of running and maintenance of the Training Centres. However, to enable the users of equipment in other sectors, to safeguard their interests in the direction of training of their personnel through these Training Centres, the training programmes may be given the shape of a joint venture, by collective participation of all the major users of equipment in the programme. They may share the cost of capital investment in the training Centres on pro-rata basis—commensurate with the value of equipment owned by each sector, and they may assure that a certain number of trainees will be sponsored for training annually through each Centre—both in the trade of operators and mechanics.

Such a detailing in this direction would ensure continuous running of the Training Centres to the mutual benefit of major owners of equipment in the country.

7.6.2 *Governing Body to control the operation of Training Programmes*

A Governing Body could be constituted for running the Training Centres with a representative each from the above-mentioned organisations. Besides the representatives from these organisations, a representative each from the Ministry of Employment and Labour and the Planning Commission may be on the Governing Body.

The Governing Body would have a Technical Sub-Committee who would delienate the curricula and syllabi and the programme of training for each class of trainee. Any additional courses to be added to accommodate the requirements of organisations like the Ministry of Transport (Roads Wing) could also be conveniently decided upon and included in the Training Programme.

7.6.3 *Organisation*

For any training programme to be successful to the desired extent, it is most essential that the best trainers are put on the job. They should be from the class of highly skilled technicians who do not only have the experience of 'do it yourself' technique, but can also express themselves meaningfully and clearly while imparting training to the trainees. Such people would, no doubt, be available; but they can be attracted only if the job offered to them is fairly remunerative, commensurate with their skill and experience.

Most often, however, on considerations of economy, such jobs are not made properly remunerative and occasionally such persons are recruited as trainers as would not possess the required degree of experience even though they may have qualified as the best students in their institutes. Employment of such students of distinction as trainers in the technical training institutes, without much practical experience (specially when they are employed immediately after qualifying through the training institutes as top-grade operators cum-mechanics) cannot do good to the trainees in imparting proper instructions on the job. Unfortunately, this has been happening in some of the Technical Training Centres.

In fact, the overall management of the training programme has also to be assigned to such persons of outstanding ability in the field of management of operation, maintenance and repair of equipment.

It is considered necessary that the training centres should be manned by persons of the rank of Joint Directors and senior technicians. They should be assisted further by skilled mechanics who may be masters in particular trades diesel engine repairs, transmission assembly repairs and repairs to various mechanical/

hydraulic/electrical systems on machines. Some of the trainers may be versatile hands who can handle with a degree of high skill repairs to a number of assemblies/components.

Such arrangement alone would make it possible for effective implemnetation of the training programmes to be enforced.

The Training Institutes may further be affiliated to a Central Directorate of Manpower Training. That Directorate may be responsible to the Governing Body to be set up for overall control of the Training Centres.

7.7 Financing

7.7.1 *Cost of Training*

To meet the requirements of training of operators, mechanics on the lines defined above, the equipment and facilities to be provided have been broadly outlined in Appendix 7.3. The capital investment to be made would amount to Rs. 20 to Rs. 25 lakhs approximately per Training Centre. The estimate as such is based on the assumption that old but seviceable equipment (about to be discarded at the end of their economic life) will be acquired.

The cost of Training of operators and mechanics would be Rs. 5000 to Rs. 7000 per trainee, as per details worked out in Appendix 7.4.

7.7.2 *Sharing the costs of training*

Though in prinicple the Governing Body alone can fix up the share of costs to be apportioned to each major organisation who would be participating in the Training programme, a rough indication in this respect, has been reckoned with by the Committee, and is as follows:—

Sector	Share
Irrigation & Power Sector, Ministry of Transport and Border Roads	50%
N.M.D.C.	50%
N.C.D.C.	
H.S.L.	
Neyveli Lignite Corpn.	

The programme of development in the fields of mining under N.M.D.C., H.S.L., N.C.D.C. and Neyveli Lignite Corporation, as envisaged at present, will necessitate substantial additions of earthmoving machines. Besides expansion programme for the existing mining operation, new mines are likely to be operative in the 5th plan period. This is where the need for training of operators for new machines will be much larger.

In the Irrigation and Power Sector, the Road Building Sector, including Ministry of Transport and Border Roads, the new equipment will be added in these Sectors largely in replacement of the existing machines.

Accordingly, the requirement of new trained operators and mechanics, cumulatively in the Irrigation and Power and Road Construction on one hand and with Iron Ore Mining, Coal Mining and Lignite Mining on the other, will be, more or less, balanced. Hence, the proposed distribution of apportionment of costs as above.

The share of capital investment would hold good for a period of five years initially and any additions of equipment commensurate with the needs of the training programme, would be shared on pro-rata basis by the participating organisations.

The cost of operation of training programmes would be met with by the organisations, commensurate with the number of trainees sponsored by them for training, subject to a minimum amount corresponding to the number of trainees they would initially agree to sponsor for training in the Training Centres.

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7.7.3 *Sources of Financing Training Costs*

In the Mining Sector, a separate provision exists for training of the personnel employed on work in Mines. A portion of such provisions could be suitably diverted to meet the expense on capital investment on equipment in the proposed Training Centres and the annual cost of training of a given number of trainees of each organisation could also be met with similarly from the same provisions.

For the Irrigation and Power Sector, it may be suggested that a provision may be made in the project estimates equivalent to one half of one per cent of the estimated cost of the project to meet the Training Programmee. 50% of this provision may be utilised by the Project Authorities for 'Inservice-training' of the people in employment, while the balance 50% may provide funds for capital investment in equipment and running and maintenance of the Training Centres for training of the trainees sponsored by the projects.

It is estimated that the investment in training would be paid back atleast 5 to 8 times through better utilisation of equipment, more production, lesser down-time of machines etc., and reduced initial investment resulting from better norms of production by given items of machines. This reckoning is substantiated by an exercise evaluating the benefits as given in Appendix 7.5.

7.8 Alternative Proposals made by Major Users of Equipment for Individual Ownership and Management of the Technical Training Centres.

While reviewing the position regarding difficulties faced by the Technical Training Centres of the CW & PC, in the matter of getting adequate response from major users of equipment in the country for sponsoring trainees to these Training Centres, discussions were held with the officers in charge of N.M.D.C., Union Ministry of Agriculture, and officers of the Bhilai Steel Plant and Rourkela Steel Plant. During these discussions, the officers concerned advocated establishment of Technical Training Centres within their own organisations in preference to their continued association or partnership with the Irrigation and power Sector in training their personnel in the Training Centres owned by the CW & PC. In fact, the Union Ministry of Agriculture have already mooted a proposal to take over the Technical Training Centre of the CW & PC at Kotah in Rajasthan.

The N.M.D.C. officers have expressed their will to establish a Technical Training Centre in Mysore State near Donamalai Mines, where the work will continue for the next 20 to 30 years.

Similarly, officers of the Steel Plants have suggested that the scope of training being imparted in their existing Technical Training Centres attached to the Steel Plants be enhanced to cover the basic requirements of training operators and mechanics for earthmoving machines and mining equipment.

The N.C.D.C. authorities have indicated that they would accept the proposition of having a training institute jointly organised by the N.M.D.C., N.C.D.C., Neyveli Lignite Corporation and Hindustan Steel Ltd., which may come under the purview of one Ministry, so that it would be convenient for them to share the capital and operating costs on an agreed basis. They have also expressed the opinion that the facilities available so far, for the training of operators and mechanics in the country, are not adequate and that there is need for imparting higher standards of training to the staff and personnel in operating, maintaining, repairing and supervising the equipment in order to achieve better utilisation of the equipment and consequent increase in production and reduction in the cost of operations.

Thus, it seems evident that while there is a better consciousness amongst the users of equipment of the basic need for formalised training and organising same in a more efficient manner, they are given more to the thinking that the Technical Training Centres, which would train their personnel, should be identified with individual organisations for running and management thereof. So long as the basic need for formalised training is admitted, such proposals would meet the requirements relating to improvement in utilisation of equipment. However, one has to consider as to how many Training Centres are required in the country and how should these be organised.

A general agreement has also arisen from most of the major users of equipment regarding possible assistance in organising and supervision of the Training Centres by the CW & PC. They are also inclined to accept the proposition for affiliation of the Training Centres to a Central Government Body already mentioned in para 7.6.2. Perhaps, the basic thinking in relation to individual owning and management of the traininig centres by respective organisations has resulted from the responsibility they have to undertake in financing the expenditure by way of capital investment in establishment of these Training Centres. This may be only a natural phenomenon. After all, anyone making an investment would also like to have a complete control of the particular assets for which the investment has been made.

Another consideration, which has been enlarged upon by some of the organisations in relation to their proposals for individual owning and management of the training institutes, is the administrative difficulties which these organisations run into when the trainees trained in the CW & PC Technical Training Centres are employed by them. This attracts certain objections from the Trade Unions and at times it is difficult to make adjustments administratively when such trainees are employed on the job. According to them, it would be more convenient for them to make all necessary administrative adjustments, if the trainees are trained in their own institutes.

7.9 Views of the Committee

Whatever may be the considerations with regard to individual ownership of the training institutes by some of the organisations or by participating in a joint venture in this regard as discussed earlier in this Chapter, the Committee is of the view that so long as the training establishments are created in a satisfactory manner under the guidance and supervision of the proposed Governing Body, it would meet the basic requirements of work with equipment. This would, of course, lead to one more question—the number of training centres to be continued to be operated under the aegis of the CW & PC.

Considering the programme of work on Irrigation and Power Projects—specially the new schemes that will be ushered in for construction—in the near future and mainly in the Fifth Five Year Plan, it is considered that two Technical Training Centres may be continued to be in operation in the Irrigation and Power Sector. One of these may be located in the Northern region and the other in the Southern region, at suitable locations. Broad outlines of thinking on part of the Committee in this respect regarding location of the training Centres has already been reflected in para 7.5.7.

7.10 Placement of trained personnel

A training programme would be ineffective if it is not coupled with proper utilisation of such trained personnel. The operators and mechanics now trained at the Training Centres are all sponsored candidates and they have to fill in a bond to serve for a specified period. The bond helps the sponsoring authority to keep the person tied to a job inspite of better offers which he gets due to shortage of trained personnel; but for the person it creates a sense of frustration. The unfortunate point with Irrigation and Power Projects and for that purpose for the construction industry in general, is that the technical hands are not needed after the completion of work. This poses a serious problem in the closing stages and unless continuity of job opportunity is assured, the workers start looking for outside jobs well in advance and also agitate for placement elsewhere which is exploited by the leaders of the Workers' Union resulting in inefficiency and low utilisation.

To attract better calibre in the operators and mechanics, it is necessary that proper wages be paid to trained hands. Training may be made a compulsory requirement for certain grades of operators. Similarly, training could be made a pre-requisite for promotion to master mechanic/chargemen/foremen etc. It would be better if in the I & P Sector, the deployment of trained personnel, their promotion, assessment of records and continuity of training is done in a centralised manner at State level under the aegis of the State Central Mechanical Unit Organisations.

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7.11 Conclusion

It would be best to consider the engineering and social values together in the matter of training, with the overall objective of doing any given item of work with the equipment expeditiously, efficiently and economically. The need cannot be very clearly measured as this would involve certain social values to the extent of measurement of human needs and response. The human needs are related more to the framework of economic outline defined by the management. The performance of the trained persons can of course, be measured progressively as more and more trained persons give better output or progress, least down-time of machines and the net cost of production being comparatively lesser, as the intensity of trained persons on the job increases. However, it will be wrong to lay a standard of measurement for such progress. The overall thinking to be developed in this matter is on the lines of the example generally quoted that an expert may tell, on hearing music the identity of the individual giving the performance, or of instruments used in producing that music. Similar is the case with a person tasting wines or liquors, who can tell as to how old is the liquid contained in the bottle by a simple tasting of it and in some cases, the expert telling as to which particular country is the wine from, or which particular wine yards the basic material would have come from. The experienced users of equipment strongly hold the same view in stressing the need for training and the results that would be manifest as a consequence of trained persons being employed on the job where intensity of equipment in use is very large. Hence, the training programme must be given due importance to the extent it is necessarily warranted and this should not be ignored or treated casually when projects or programmes are planned for execution to involve large scale mechanisation.

The functions for a successful training programme ultimately get to be the responsibility of the management. The need for in-service-education in training continues to increase as equipment becomes larger, more expensive and more complicated; as design becomes more intricate and involved; as labour becomes more demanding; and as overall management becomes more important. Good Managers must continue to update their knowledge of equipment, materials, labour, communications, financing, construction methods & management techniques, and truly effective managers must see that their employees—from labourers to top managers, also continue to upgrade themselves. Need is there and the methods of accomplishment are all around us. It is the management's role to bring the two together effectively, fully meeting the financial and administrative needs in a co-ordinated manner.

Best recognition to this admitted principle can be given (i) by providing for financial resources and funds for 'Training' in the main financial estimate of the work where equipment will be deployed;

(ii) Allocating part of these finances to Centralised Training Schemes for training Supervisors, operators and mechanics;

(iii) Using a part of the finances for 'in service' 'on the job' training on projects;

(iv) Using relatively modern equipment, methods and aids for training and discarding obsolete items previously in use;

(v) Recruiting trainees from a class of educated people—with I.T.I./Diploma in Mechanical Engineering qualifications;

(vi) Following a programme of "Search & Research" in the matter of 'training programmes and standards'; and

(vii) Providing for coordination and organised control of the Technical Training Centres through the proposed Governing Body who would in principle act on the same lines as the Directorate General of Empolyment and Training who have the whole lot of Industrial Training Institutes in the country for training of craftsmen in different trades (other than the operators and mechaincs of principal items of earthmoving machines and construction plant).

7.12 Summary of Observations and Recommendations

The programme of training of Operators and Mechanics has been effectively introduced by the Central Water and Power Commission under the Ministry of Irrigation and Power. Most of the major users of equipment in the country have availed themselves of the training facilities so established. Even though the demand for qualified trainees has not exceeded the established capacity for such training, the need for increase in this capacity is underlined by the annual additions of equipment in various sectors/industries in the past and the envisaged programme of development in these industries in the future. If the programme of manufacture of indigenous equipment is to be the index for home consumption of such equipment, the country would require annually a minimum of 500 Operators and 250 Mechanics (additional hands). To meet this requirement, it is necessary to augment the existing capacity for producing trained Operators and Mechanics.

The need for formalised training programmes is admitted by all major users of equipment. Some of them are considering to establish the Training Centres individually under their own administrative control.

The equipment and facilities in the existing Technical Training Centres of CW & PC is very old and obsolete. In addition, the method of training in vogue produces Operators-*cum*-Mechanics. The Operators do not have specialised training in operation of individual items of equipment and the Mechanics do not undergo a rigorous course for clear understanding of the method and process of repairs to mechanical systems, assemblies and sub-assemblies comprising the machines.

In order to meet the future requirement of trained Operators and Mechanics for machines that will be deployed on new schemes, and to make the training programmes more effective than what they are at present, the following steps would have to be taken: —

(1) A Central Agency be created for coordination amongst different departments organising formalised training programmes for training of Operators and Mechanics so that the syllabi of training could be properly laid down and the method as well as provision of facilities and equipment for imparting the training, could be properly defined. This may be achieved by constituting a "Governing Body" comprised of representatives from the Mining Sector, Irrigation and Power Sector, and the rest of the users in the country. A representative each from the Planning Commission, Directorate General of Employment and Training (Ministry of Labour, Employment and Rehabilitation) should also be the Members of the Governing Body.

(2) The equipment and facilities in the existing Technical Training Centres of the CW & PC should be suitably remodelled so as to have equipment of more recent origin, the like of which is currently in use on projects and to reorient the method of training—by introducing short—term courses for Operators' training (Specialised Operators for individual categories of machines) and long-term courses for training of Mechanics.

(3) In order to make Project/State authorities in the Irrigation and Power Sector partners with the CW & PC/Ministry of Irrigation and Power in the matter of organising the training programmes, provision should be made in the project estimates from one-fourth of one percent to one half of one percent, of the estimated cost of the project for training purposes. 50% of this provision could be used for in-service-training on the project and the balance could provide funds for contribution to the Technical Training Centres for training the sponsored nominees of the Projects/States.

(4) Advance planning should be done by the Project authorities for training of Operators and Mechanics, so that on arrival of the equipment at the project site, the trained Operators and Mechanics alone can handle the machines.

(5) Recruitment of trainees should be made from amongst the I.T.I. qualified personnel, or Diploma holders in Mechanical Engineering.

(6) The overall management of the training programme should be assigned to persons of outstanding ability in the field of operation, maintenance and repair of equipment.

(7) The Training Centres should be manned by persons of the rank of Joint Directors and suitable engineers assisted further by skilled Foremen and Mechanics.

(8) The Central Water & Power Commission should continue to run a minimum of two numbers Training Centres. Simultaneously, consideration should be given to the relocation of the Training Centres based on the convenience of the project authorities sponsoring the trainees, or in view of the concentration of construction activities in certain areas on long term basis. Broadly speaking, one Training Centre should be located in the Northern Region and the other in the Southern Region, at suitable places.

(9) To attract better calibre for recruitment as Operator and Mechanics trainees, proper wages should be paid to the trained hands.

(10) Training should be made a compulsory requirement for certain grades of Operators and Mechanics and it should be made a prerequisite for promotion to higher grades Chargemen, Foremen etc.

(11) In the Irrigation and Power Sector, the deployment of trained personnel, their promotions, assessment of records etc., should be done in a centralised manner at State level, under the aegis of Central Mechanical Unit.

CHAPTER 8

DATA ON PERFORMANCE OF DIFFERENT ITEMS OF EQUIPMENT OF VARIOUS CATEGORIES/MAKES

(a) Technical assessment;

(b) Norms of schedules of working hours and life of equipment of various items;

(c) Actual performance of various items of equipment in different projects in various sectors in terms of average annual utilisation and the life usefully spent on different jobs over given periods;

(d) Major repairs and field repairs—charges over the last ten years, in respect of various items of equipment in terms of:

(1) spare parts; and

(2) labour.

8.1 **Scope.**

The subject matter of this term of reference may become wide-embracing and too elaborate, if the large number of categories of machines classified as "Construction Plant and Equipment" and the multiplicity of assorted makes and models of equipment in each category are dealt with individually. The number of makes of equipment in use in the country in relation to each category of such equipment has been described in Chapter-1 on "Appraisal of the construction plant and equipment in the country." This would clearly indicate the magnitude of the data that may have to be specifically detailed if the approach is to be to cover performance of equipment in different categories by makes and models of machines.

The actual performance of different items of equipment of various categories and makes in relation to individual projects/departments/sectors, where the machines are in use, has been clearly reflected in the statements given in various Appendices regarding utilisation, repair costs etc. etc. The discussion on any particular aspect relative to "Equipment Economics" of any make of machine in a particular category, on a comparative basis and in inter-relation to similar equipment of different makes, may result in certain controversies, as some of the suppliers of equipment may challenge or question the details of the information elicited or opinions expressed. Hence, the 4 sub-items (a) to (d) under this term of reference would be dealt with in this Chapter in a general manner.

The basic underlying consideration in dealing with each one of the 4 items would be the "Equipment Economics".

8.2 **Technical Assessment on Performance of Various Items of Equipment**

8.2.1 *Performance related to Design and Construction Features*

The performance of any item of equipment of any category/make is to be basically judged in terms of its productivity in inter-relation to its rated capacity as per specifications and type of end product produced by the machine, its maintenance and repair costs and the breakdowns suffered by it during the course of its employment on the job, indirectly reflecting the soundness of its technical design and construction features and its suitability for a given application. While the cost of maintenance and repairs and the end cost of the product produced by a given machine are subjective aspects, which are related to many other factors, involving human elements-proficiency and skill of operation, repair and maintenance—the facilities created for timely attention to preventive maintenance work and its implementation as well as the overall management and control of operations with equipment, (where a large number of machines are in employment at one place), the other elements of consideration as defined above, relate mainly to the inbuilt and inherent qualities of the particular make and model of the machine of a given category of equipment. The performance of the machine would be commensurate with the quality of the materials used, the degree of perfection with which the design and construction of the machine has been adopted and the efficiency of the particular "Systems" as integrated in the assembled machine.

8.2.2. *Comparison of Performance of Various Items of Equipment*

The items of construction plant and equipment being very expensive-their price ranging from Rs. 1 lakh to over Rs. 100 lakhs in some cases (the Excavators in use with NCDC and Neyveli Lignite Corporation can be classified in the upper range of value), certainly the manufacturers of equipment would normally be expected to make the best 'input' by way of design and construction features and the quality of materials used in manufacturing it. With the advance in technology in every direction, it would have to be generally assumed that so long as the origin of equipment is identified with manufacturers of repute (whose products have been performing well in the past), the machines marketed by such manufacturers would be expected to give generally satisfactory performance. Therefore, at best there is to be a relative degree of comparison of the performance of the machines of different makes in a given category of equipment—one make of machine may perform better than the others in actual practice, while employed together on a job and this may form a basis to judge which machine gives relatively the best performance.

8.2.3 *Judicious Purchase Prerequisite for Desired Performance*

8.2.3. *job condition.*

Such comparative study, however, can be made only after the machines have been purchased for a given item of work in full consciousness of the conditions of work, the requirements of work, the facilities that are available with the user with regard to efficient operation, maintenance and repair of the machine. What is therefore, important is to define these conditions even prior to the purchase of equipment. This is basically essential for making the most selective choice of a machine for a given job.

In some cases—specially in case of integrated plants, the design of various components of the plant is to be so tailored as to give a fully synchronised operation of various components in order that the plant as a whole, can meet the rated output specifications and besides it is economical in terms of end cost of the product produced thereby.

In both these cases, whether it is a "Ready for use type machine", or an integrated plant, it becomes necessary that the prospective user of equipment details his requirements in specific terms. This he can do only if a proper plant planning exercise is carried out by him, considering the overall cost of operating and maintenance of a machine or a plant with various combinations of equipment.

For the "ready for use type" of machines, only a few makes may meet the requirements of the user in relation to job conditions and situations. Here again, further considerations would arise in relation to standardisation, after-sales-service provided by an agent/distributer of the particular makes of machines, ready availability of spare parts for the machines and the assessment regarding standard of performance of particular makes of machines which might have been in use elsewhere or on other jobs in the country. Unless these considerations are given due weight as they deserve, it would be of no avail to keep judging the performance of the machine on a given job after its purchase. The main idea of being cost conscious in initial purchase of equipment is to buy "economy" rather than simply acquiring a physical property—a machine.

8.2.3.2 *Standardisation*

No doubt, most of the popular competitive makes of machines in given categories have comparable technical design and construction features to offer; and therefore, some times, it is difficult to reject in competition those machines which meet the advertised tender specifications. Each make may have certain plus features in one of their machanical systems on the machine and these would be attributable to the peculiar design features of individual makes of machines. Hence, greater emphasis would have to be laid on standardisation of equipment on a project and evaluation of cost data on maintenance and repair of machines of different makes corresponding to results obtained by the use of these makes of machines on other projects. Here the aspect of record keeping assumes paramount importance, as such decisions based on comparative study of performance data cost-wise would be as correct as the recorded information would be. Such record can clearly establish the cost of maintenance/repair of particular makes of machines and accordingly illustrate the degree of reliability afforded by it in terms of mechanical availability whether the down-time due to breakdowns and repairs is substantial or little on comparative basis for various makes of machines in the same category, relative to a given job application.

8.2.3.3 **Total cost economy**

This cost data is to be further related to the production achieved by given makes of machines. After all, the economy in use of a particular make of a machine can be judged by the return it gives in terms of total production and total cost in its life time.

Briefly speaking, the study of performance of the machines is mainly related to certain cost figures—the cost of ownership and operation of the machines in its life time. Such studies can only help to judge precisely the 'Equipment Economics' relating to different makes of machines. To illustrate this further, the subject of "Equipment Economics" covers investment costs (including depreciation or replacement cost and interest charges), down-time costs, obsolescence costs and repair and maintenance costs. While in relation to investment cost and obsolescence costs, no separate records need being maintained for assessment of expenditure (these being annually fixed costs or fixed costs even on hourly basis), in respect of maintenance and repair costs and down time costs, the details of actual figures of expenditure on maintenance and repairs of a given item of machine and the time for which the machine was not actually available for work due to mechanical breakdowns, have to be clearly evaluated and recorded.

8.2.4 *Difficulties Faced by Committee in Proper Evaluation*

The Committee have attempted to collect and compile information in this respect; but it has not met with success to the desired extent. The inadequate records available with the users of equipment and the varying pattern of records maintained have made it difficult for ready compilation of the required information of running and maintenance of the machine and therefore, the Committee have found it difficult to express any concerted opinion regarding comparative costs of particular items of works carried out by different makes of equipment in the same category. The only uniformity noticed is that in relation to the basis of estimation of costs of different makes of machines in the same category for particular items of work under different conditions but in so far as the actual expenditure figures are concerned, itemised information being not readily available, the "Equipment Economics" relative to different makes of machines cannot be precisely judged.

8.2.5 *Inadequacy of Data to evaluate Factors of Equipment Economics*

What has contributed towards this being not properly done by the users of equipment, has therefore, been gone into by the Committee. Their findings regarding such reasons and their relevance to technical assessment is explained in what follows.

8.2.5.1 *Maintenance and repair costs*

It has been a normal practice for the Irrigation and Power Projects to account for expenditure on account of element of cost of repair of equipment by charging to the work a certain estimated amount on hourly basis (on which the machine was used). The actual expenditure as incurred on repairs, though reflected in the annual work abstracts relating to particular estimates, is not accounted for separately for progressive examination in terms of cumulative costs year after year. Besides this, individual items of equipment being employed on different items of works year after year, the expenditure on repairs on such machines gets accounted for in different estimates. Further more, the estimates of major repairs to equipment cover individually a group of machines of the same make and model and the expenditure in relation to individual machines is generally not separately recorded for ready reference.

8.2.5.2. *Down-time costs*

Meticulous care is not taken to indicate the periods for which the individual machines were idle due to breakdowns and repairs. What is generally assessed is the overall utilisation of the equipment annually in relation to a basic schedule of working hours predefined for the given categories/types of machines. Hence it has not been possible to evaluate 'Down-Time Costs'.

8.2.6 *History Sheets Record—a Guide to Technical Assessment*

The History Sheets as maintained for individual items of equipment provide for clear details of the types of break-downs the machines would suffer in the course of their employment on the job. However, in practice, even this record is not well-maintained; and it is difficult to judge precisely the frequency at which particular kind of types of breakdowns occurred repeatedly on given machines. Such 'History Record' in fact would provide the main source for observations leading to "Technical Assessment" and proper evaluation of the performance of the machines of different makes, models and categories.

8.2.7 *Data Collected for Technical Assessment*

The Committee have collected information in this respect from the users of equipment in different Sectors. The information relates to a variety of items of equipment of different countries' origin, though some of the observations relate even to some items of earthmoving machines included in the "List of Standardisation of Earthmoving Machines" as last compiled by the Standing Committee of Experts on Standardisation of Earthmoving Machines.

A gist of the technical defects noticed in items of equipment of different makes and of different countries of origin, has been prepared and is at Appendix 8.1.

8.2.8 *Observations of Committee on Performance of Imported Equipment*

(i) Items of equipment other than those included in the "List of Standardised Items of Earthmoving Machines" were in most cases, imported into India for the first time. These could be generally classified as untried/unproven items. The reasons for purchase of such items and the resultant assortment of machines, collected in different categories in the country, have been dealt with elaborately in Chapter 1. The main point to be mentioned in this respect is that even if foreign exchange resources impose restrictions on selective choice of equipment from stand point of country of origin of equipment, the bulk purchases of equipment of new makes should be resorted to only after a smaller quantity thereof has been put to proper tests and trials and the need for technical modifications in the design and construction features of the machines clearly determined in relation to the job conditions obtaining in India.

(ii) The type of breakdowns suffered by such untried equipment often relate to the poor "Ageing" quality of the parts/components of the machines.

(iii) The quality of workmanship generally appears to be below standard (in comparison to the equipment included in the List of Standardised Items).

(iv) The design and construction features of these machines do not generally compare well with the latest models of the standard items of machines in the same category. It may not be wrong to make an observation that sometimes such equipment corresponds to obsolete models of standard equipment.

(v) The design characteristics of individual components and systems on these machines leave a lot to be desired. For example, the hydraulic system—the rubber parts in the system—have often caused breakdowns, which at times could be considered as hazardous from standpoint of safety in operation of machines.

(vi) The down-time of these machines (for repairs), has generally mounted to very long periods due to inordinately delayed supplies of required spare parts. This is further attributable to unsatisfactory after-sales-service rendered by the distributors/agents of such equipment in the country.

Firms of goods standing, who had been in the past dealing with agencies/distribution of standard items of equipment have generally not felt attracted towards such nonstandard new items, and therefore, the principals abroad have listed the services of some new concerns in this trade, who did not have substantial experience in this particular line.

8.2.9 *Observations of Committee on Performance of Indigenous Equipment*

Besides the imported items of equipment, it would also be necessary to review in relation to technical assessment, the performance of the indigenously manufactured machines. The major items of equipment which have a substantial production and turnover in the country and used by Mining Industry, Construction Industry, Road-making and Land Reclamation Departments, are the following:—

(1) Excavators.
(2) Crawler Tractors.
(3) Motorised Scrapers.
(4) Off-the-Highway.
(5) Wheeled Loaders.
(6) Motor Grader.

8.2.9.1 *Preformance*

The first high value item produced was that of 'Excavators'. At the initial stages of manufacture of this category of equipment in the country, in spite of the imported content of the machines being fairly high, certain troubles were faced due to premature failure of some of the parts indigenously manufactured. This was also true of another item later, viz., Crawler, Tractors. However, over the time, these troubles have been got over through the process of research and development as well as improvements made in the quality of material used, and proper 'heat treatment', so as to get the proper ageing quality therefrom.

Items of "Off-the-Highway-Dumpers", Scarapers, Graders, Loaders and Crawler Tractors of higher horse power—250 h.p., are undergoing the same process of development at the present time. The quality of workmanship has necessarily to improve further if the machines are to give satisfactory performance on comparative basis with other standard items previously imported from abroad (in the same category).

8.2.9.2 *Service organisation*

The service organisation of the indigenous manufacturers has to be suitably developed so that they can technically analyse the causes of breakdowns and recommend remedial measures necessary to be taken by the manufacturers for proper improvement of the 'Product'.

This service organisation would also perform the function of co-ordination between the original equipment manufacturer and the ancillary industry feeding certain components and parts in the course of manufacture of the integrated machines. This coordination would be mainly in the field of technical standard and quality of goods supplied by the ancillary industry and the quality of performance. Cases have come to notice where due to defects in Diesel Engines, tyres and the electrical system etc., (the components and parts supplied by certain manufacturers in the ancilliary industry to the original equipment manufacturer, having not given proper performance), the users of equipment had to keep the indigenous machines idle for fairly long periods. The manufacturers/suppliers of equipment, who are otherwise directly responsible to the users of their equipment, had to make substantial effort in motivating the manufacturers of these components/parts to attend to the breakdowns on the machines or to go into the causes of such breakdowns. The suppliers of these components/parts worked in isolation and not in conjunction with the service organisation of the original equipment manufacturer in analysing the position and determining precisely the causes for such breakdowns. In some cases, due to defects in some of these parts, the parts/components used by the original equipment manufacturer himself had suffered damage and the basic design of the machine and the quality of the parts used by the manufacturer were put to question.

If the service organisation of the manufacturer keeps close liaison with the service organisations of the ancilliary industry-mainly with regard to major items of components/parts supplied by them—both could jointly consider such matters technically and make amends for any serious defects in the machine, if necessary, even by reference to the Principals of such equipment abroad in whose collaboration the equipment is being manufactured in India. From research and development angle, such coordination and liaison is very necessary on part of the manufacturer of equipment with the ancilliary industry, suppliers of components/parts for those machines. Unless this is done, the ancillary industry would not come up properly in developing their products to the required extent.

8.2.9.3 *After sales service*

Another important aspect is the after-sales-service by the manufacturers of indigenous equipment or their distributors. In spite of the items of equipment being called "indigenous", the spare parts are not stocked by them to meet the requirements of the users of such equipment. Even the initial supply of spare parts which is supposed to be made with the new machines, is not arranged for in proper time. A time lag of 7 to 8 months is generally there between the time of supply of the machines and the time of supply of the total quantity of initial supply of spare parts—10 to 15% of the cost of the machines.

The degree of reliability of the indigenous machines may generally be expected to be better than that of the corresponding imported machines, as ready supply of spare parts from within the country would ensure quick repairs and least down-time. This, however, has not been attained in practice so far.

The manufacturers of indigenous equipment, when questioned about the nonavailability of parts for their equipment have generally indicated that the users of equipment are not indenting spare parts for stocking at their work sites. In some cases, for obsolete models (as with the foreign collaborators) of equipment, they have recommended bulk purchase of spare parts on 'life time buy' basis. This amounts to creation of reserve stocks of spare parts in smaller pockets with a large number of users of such equipment. This would amount to a financial liability on collective basis, of a very high magnitude. If, on the other hand, the manufacturers of equipment or their distributors arrange to stock the parts at their end, the total investment to be made by the individual users of such equipment would be substantially lower and this would help avoiding unnecessary blocking up of capital and holding much larger inventories of spare parts. This is a matter which requires serious attention.

8.2.9.4 *I.T.C. policy for imported parts for indigenous equipment*

Another important point made by the manufacturers of equipment with regard to stocking of spare parts, relates to the difficulty faced by them in import of spare parts mainly in consequence of the provisions of the import trade control policy. The restrictions imposed in the import of certain category of spare parts makes the biggest handicap in this respect. The I.T.C. Policy is always under progressive examination so as to cause its revision to the necessary extent in specific context of practical difficulties generally experienced by the users of equipment.

Even if the import trade control policy is to be suitably modified, it would save the country a substantial amount of foreign exchange and the capital to be blocked up in stocks of spare parts in different pockets at different locations in the country, if the manufacturer of indigenous equipment are allowed to stock these spare parts commensurate with the scale of consumption of high value items for various items of machines. A beginnig has necessarily to be made in this direction by establishing a well-organised inventory cell by the manufacturer himself and in keeping proper record of the age in service life of the machine with different users (in respect of the machines supplied by the manufacturer). Unless this is done, the stocks of spare parts will keep mounting higher and higher with individual users of equipment.

Even otherwise, in the interest of economy, the inventory of spare parts is to be scaled to the minimum possible limits as the inventory holding costs amount from 15% to 20% of the cost of the items. If extra stocks are carried at each place, we would be unnecessarily incurring an expenditure of Rs. 15 lakhs every year for every Rs. 1 crores worth of spare parts so stocked. In addition, further loss will be incurred due to loss in opportunity value of blocked up money. The magnitude of total loss incurred every year may amount to 40% of the investment.

8.2.9.5 *Research and development*

It is also pertinent to indicate that, while the pioneers of such equipment abroad are continually introducing changes in design of individual items of equipment—making them more sophisticated for lesser expense on maintenance and for better productivity, we continue to manufacture only the old models of machines. It is imperative that research and development sections attached to the manufacturing organisations should make continuous advances on the technological front and should keep pace with such developments abroad and consequently, improve upon the machines, so that these are more productive and lesser expensive on maintenance account etc.

There are, however, certain reservations to be made while making the observation as above. Any manufacturer undertaking manufacture of equipment for the first time, can illafford to consider improvisations in technical features of the machine with a view to bringing out an entirely new model of the machine to replace the old one. This is mainly from standpoint of economy in production costs. All the same, it has to be emphasised that once the manufacture has started and lasted for a reasonable period, the process of research and development should lead the manufacturer to consider introduction of newer models which may incorporate improvements over the previous models—making the machine more economical on production costs at home and being internationally competitive.

8.2.9.6 *Selection of equipment for manufacture*

With regard to equipment of indigenous origin, it is also to be stressed that more judicious selection is primarily made whenever a new item of equipment is to be manufactured. It is unfortunate that for various reasons some items of equipment selected for manufacture in the country are not the best that we could aim for. Notwithstanding the handicaps arising out of restricted choice in such cases for collaborations abroad, at least for the future we may attempt to evaluate technically the standard of the machine before it is decided to be introduced for indigenous manufacture in the country. Success in this direction could be partially achieved with the functioning of the Equipment Planning Committee as referred to in para 6.3.2.5. of Chapter 6.

This aspect assumes still greater importance, if we have to compete with other reputed makes of standard equipment in foreign countries in the future. It is not the home consumption alone of the equipment produced in the country, which will assume an isolated importance; the international trade aspect (from export angle) would have also to be properly considered.

8.2.9.7 *Healthy competition in indigenous manufacture*

One more point which has to be mentioned (even in isolation), is that relating to the manufacture of Diesel Engines in the country which generally power most of the items of earthmoving machinery and other mobile construction plant and equipment. The Committee considers that there should be healthy competition in this respect also as the cost and the performance of equipment is mainly dependent upon the efficient performance of the power unit installed thereon. Further more, from standpoint of economics in operation of machines, a particular type of engine alone may not always be best suited for a given machine or in relation to given job applications where the machine would work. It might be prudent to introduce at least one more popular make of Diesel Engine in the country for powering the mobile items of construction plant and equipment. As it is, it has taken fairly long for the Diesel Engines, currently powering the equipment, to develop to a stage of satisfactory performance. Some of the users of equipment have laid stress on this point.

8.3 Norms for Schedules of working Hours and Life of Equipment of Various Items

8.3.1 *Norms for Schedule of Working Hours*

In so far as the schedules of life of equipment ing hours are concerned, the subject has been dealt with in para 2.3.6. of Chapter 2 in relation to "Assessment regarding level of utilisation of equipment." The table at page 2-7 will be referred to in this regard.

8.3.2 *Defining the Scheduled Life*

In so far as the schedules of life of equipment in terms of hours of operation in life-time are concerned, it is considered necessary to understand clearly the significance of the term 'schedule life' in relation to items of construction plant and equipment.

The life of a machine may be expressed in two ways (i) the physical life and; (ii) the economic life. Colloquially speaking the physical life of an asset is the period during which it is in use till the time it is retired from the work. However, in economy, the patterns of the future depreciation of assets must be predicted in this case items of machines. When the machine depreciates through use a prediction must be made of the extent to which it will be used. The rate at which depreciation progresses while the machine is in use must be established. This would be governed more by the physical conditions under which the machine works and the situation where it is employed. Therefore, the life of the machine has to be predicted or pre-determined.

The two aspects of the life—the physical life and the economic life of a equipment will be dealt with separately.

8.3.3 *Life as prescribed in various Publications*

Much has been written by various authors on this subject concerning service life of equipment. The manufacturers and suppliers of equipment have also published literature and compilations summarising the life for depreciation purposes of various items of equipment in different situtions. Unfortunately, such data are only of limited value as a basis for predicting the service life of a particular item of equipment. In most cases, the information that is available consists of tables showing the average life of various types of structures, machines and so forth. These have been prepared by people of various degree of competence and ability. In any event, they are largely based on judgements only. In a large number of cases, such judgements arise mainly from the profitability aspect of continued use of the machines as also in specific relation to the Income-tax law.

8.3.4 *Life to be Defined in Number of Years*

Granting that our main effort is to recover the ownership expense, an estimate of predicted service life of machine has to be properly framed so that the rate of recovery of amount of ownership expense is clearly established on the analogy of recovery of interest charges on capital investment. The life in that case is fixed in number of years which is taken as the service life of the machine.

Another consideration which has led the Committee to such conclusive thinking for fixing the life of the machines in years is the fact that utilisation of equipment by most of the users has been rather poor- -leaving aside some exceptional cases. It is a matter of general observation that the users are not mindful of the end costs of a work with machines, if they have to account for depreciation on hourly basis by adopting life in number of hours. They generally fail to realise that if a machine is not used intensively, the effect of obsolescence is tremendous, due to physical deterioration of the machine over long period in years. And also that the operational cost (by way of Operators' wages and labour charges of maintenance staff), which are reckoned on annual basis, are much more on per hour basis, when compared to the corresponding figures of costs of these elements, if the machine is made to run for longer number of hours during a given year. Similarly, the overhead cost also gets to be disproportionately higher, when lesser number of hours are clocked each year.

The current assessment of equipment life being related to lower costs, higher productivity and higher profits (from commercial angle), the economic life of any piece of equipment is that which yields maximum return to the owner during the life of work. The revenue from a machine generally declines as it ages. Loss of horse power and productivity, down-time costs and the physical deterioration due to wear and tear or obsolescence, all contribute to the diminishing returns as the machine grows older in age. It is most popular to fix equipment life in order to minimise costs. This is done by assuming a longer life of the machine in number of hours and thus booking much lower figures of depreciation costs to the job. This is fallacious.

Hence, we have to reconcile ourselves with more compatiable thinking with regard to figures of physical life of the machine which may earn a proper depreciation reserve, make the overall cost of work with machines economical and simultaneously provide incentive to the users of equipment to use the available equipment more intensively year after year, so that the minimum possible number of machines can be made to do a given volume of work.

In fixing the life of equipment in number of years and thereby fixing the total amount of depreciation for a given item of equipment per year at fixed percentage depreciation basis, the owners of equipment would consider with greater attention the need for using the machine more intensively each year, so that the depreciation costs per hour are the minimum possible, and the fact of obsolescence of equipment does not make iteself manifest on the job too largely.

8.3.5 *Physical Life and Economic Life*

The physical life of a machine is the lifetime over which it is physically able to produce a profit in the absence of technological improvements. The economic life is the life over which it can profitably survive even in the face of improved models, changes in methods and techniques and other variable economic influences. In modern world the technological progress in the field of manufacture of construction equipment has been so rapid that the competition from improved new models of machines has forced the old equipment into economic decline. However, for the developing countries like India, where the indigenous manufacture of such equipment is of recent origin, the competition has not been brought to bear with economic aspect of depreciation. The two aspects of physical deterioration and economic decline are no doubt interrelated in a way. The net earnings of a machine decline with both age and hours of operation. The quality and quantity of product also decline simultaneously as the physical deterioration takes place. Hence, even in isolation the physical life is determined in relationship to the economics of work with given items of machine.

To annotate this further, it may be mentioned that with the progressive ageing of machine in use, the maintenance and repair costs keep mounting high and with physical impairment of the machine over a time the production gets reduced thus resulting in higher end-cost of the product.

The economic life gets to be of great functional value when planned replacement of equipment are necessitated to meet the market competition in respect of cost of endproducts of these machines.

8.3.6 *Factors Influencing economic Life*

As already stated, the economic life gets to be of great functional value when planned replacements of equipment are necessitated to meet the market competition in respect of cost of end product of these machines. In that case, a consideration arises that the present assets/machines, may not be retired on the basis of the life estimated for them at the time of purchase of machines. The main factors influencing replacement decision would be (1) Inadequacy; (2) excessive maintenance costs; (3) declining efficiency, and (4) obsolescence.

8.3.6.1 *Inadequacy*

Any piece of equipment that is inadequate in capacity to perform its required services, is logically due for replacement. Consider a Belt Conveyor of a certain length, for example, for which initially a 20 h.p. drive motor was purchased. After a year, it was decided to double the length of the Conveyor, which necessitated replacement of the motor by a 40 h.p. one, or addition of another motor of 20 h.p. The decision in favour of one or the other alternative can be made through economy study.

8.3.6.2 *Excessive Maintenance Cost*

Excessive maintenance costs and declining efficiency results from physical impairment of equipment. For example, physical impairment may reduce capacity of a bull-dozer to move earth and consequently, reduce the value of the service it can render. Fuel consumption may rise, thus increasing its operating costs. Larger down-times may necessitate heavy expenditure on repairs and may even lead to induction of additional equipment into total operations, if a time bound programme or given targets of production have to be achieved.

8.3.6.3 *Obsolescence*

Obsolescence occurs as a result of the continuous technological improvements of the tools of production. Often, the improvement is so great that it is economical to replace a machine even in good operating condition with an improved unit. In some cases, the size of the job or activity on which a piece of equipment has been used, declines to the point when it becomes advantageous to replace the machine with a smaller unit. In either case, replacement is due to obsolescence. Therefore, obsolescence is characterised by changes external to the asset and is used as distinct reasons in itself for replacement where warranted.

8.3.6.4 *Economic life with constantly increasing maintenance cost*

Economics of replacement of equipment arise mainly from the constantly increasing maintenance/repair costs with the ageing of the machine. To simply illustrate the economic history of a machine with constantly increasing maintenance costs, let us assume that a piece of equipment was purchased for Rs. 100,000, that

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its salvage value is Zero and that its maintenance cost is zero the first year, and rises at a constant rate of Rs. 10,000 per year. Because there is a rising trend in the maintenance costs, there will be a minimum average total cost at some point in the life of the asset. To determine this, let the following tabulation be done:—

End of year number	Maintenance cost for end of year given	Summation of maintenance costs B	Average cost of maintenance through year given C÷A	Average capital cost if retired at year end given 100,000÷A	Average total cost through year given D+E
A	B	C	D	E	F
1.	0	0	0	100000	100000
2.	10000	10000	5000	50000	55000
3.	20000	30000	10000	33333	43333
4.	30000	60000	15000	25000	40000
5.	40000	100000	20000	20000	40000
6.	50000	150000	25000	16666	41666
7.	60000	210000	30000	14290	44290

The point of minimum cost in this case occurs in the 4th and 5th years of the life of the machine. As from the 6th year onwards, the average total cost through years given starts increasing above the figures for the 4th and the 5th year of the life of the machine.

8.3.6.5 *Present worth factor in determining economic life*

There are a number of mathematical equations which integrate the variable of increasing maintenance cost etc., and enable one to come to a figure of minimum cost life with increasing maintenance cost. It is not the intention of the Committee to go into these mathematical functions in any great detail. In fact, to work out the actual figure of minimum cost, life for a given item of equipment, one has to necessarily summarise various elements of costs in terms of "Present worth" of various figures. For instance, maintenance cost at the end of a year as shown in the above example, would have to be reduced to "Present worth" by adopting a certain rate of interest and determining the multiplication factor corresponding to each year of life of machine. Besides this, the capital recovery amounts for each year under consideration, will have to be added to obtain the annual figures of maintenance plus capital recovery with return. This again is a fairly involved procedure. However, the summation of all these factors would generally take the form of a curve below:—

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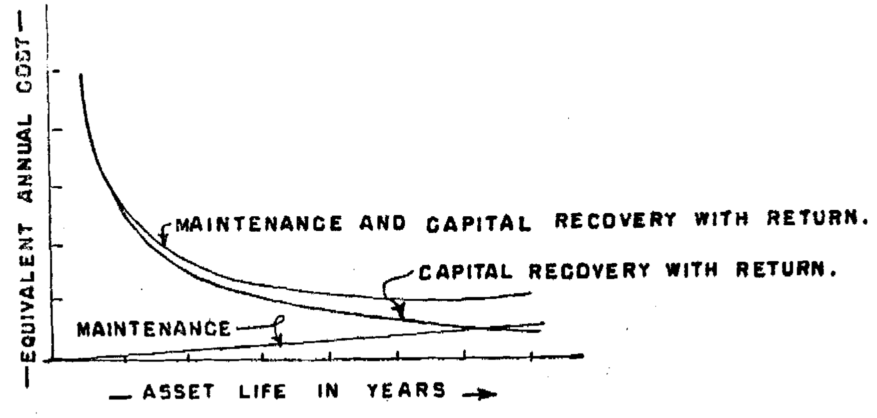


MINIMUM COST LIFE OF AN ASSET WITH CONSTANTLY INCREASING MAINTENANCE COST

8.3.6.6 *Economic life as reckoned by the Committee*

If other factors like physical impairment or declining efficiency of the machines and obsolescence costs have to be combined in the exercise for determining the economic life of machines, the mathematical equation gets further involved and complicated. However, since the aspect of obsolescence would not have a direct bearing on the equipment in use in our country, specially when more and more indigenously manufactured items of equipment are to be put to use without change in makes and models over long periods, the consideration regarding obsolescence has not been taken into account for purposes of the study carried out by the Committee. The consideration regarding economic life has, therefore, been limited more to the excessive maintenance and repair costs and the possible decline in efficiency of machines. Assuming that a certain amount of in-put will be made into the machines by way of increased repair costs, the machine is assumed to be maintained in operation with a certain minimum efficiency. With regard to inadequacy of equipment this is more an exercise of plant planning and has to be dealt with separately and not necessarily in relation to the economic life of the equipment.

8.3.7 *Evaluating the Life of Equipment*

8.3.7.1 *Analysis of data as collected from users*

The Committee have collected data regarding year of purchase of different items of equipment working with various users in different sectors and the total hours of operation of the machines so far (upto the end of 1970). Information has also been compiled in respect of hours of operation of these machines over a period of 5 years upto November, 1970. Whereas the users have felt it convenient to give the data regarding total hours worked by the machines from the time of their purchase, in relation to the operational hours for the defined period of 5 years preceding end of 1970, information has been given only in 50% of the returns filed with the Committee.

Selective sampling has been done as per Appendix 8.2 to illustrate the maximum number of hours of operation of certain machines, corresponding to the number of years the machines have been in use.

It may be seen from this Appendix that some of the machines have clocked 20000 hrs. to 30000 hrs. in a period of 10 years to 15 years. Some items of machines—principally Cranes, have clocked more than 40000 hrs. in a period of 15 to 18 years. As opposed to this, in certain cases, the machines have clocked less than 5000 hrs. even in a period of 10 to 14 years.

In relation to annual utilisation of machines during the last five years, preceding end of 1970, a separate analysis has been made for the five major categories of equipment, viz., Excavators, Crawler Tractors, Dumpers, Motorised Scrapers and Cranes. This is given in Appendix 2.2. Side by side, with the figures of average total hours worked per year per machine during the last five years, the average annual utilisation during the entire period the machine was in the use since the time of its first commissioning, have also been furnished therein.

It may be seen from this Appendix 2.2 that in some cases, the machines have been utilised for more than 5000 hrs. per year (these are machines purchased as late as 1969) while some of the machines have clocked more than 2000 to 2500 hrs. per year, over a period of 5 to 6 years of their service life.

As also already stated, it has not been possible to get the necessary data regarding maintenance and repair costs of machines from different users in as detailed a manner as the Committee would have normally desired to have. It has therefore, been difficult to make a clear assessment as to how economical is the operation of those machines which have already clocked 20000 hrs. to 30000 hrs. of operation over a period of 10 to 15 years. On the face value of these figures, however, it can be only stated that had the machines not been useful to the user in giving certain production at reasonable rates, they would have discarded the machines.

Hence, it is evident that the physical life of machines in use varies from one user to another, depending upon the conditions in which the machines are used, the job application, the input that is made by way of repair and maintenance costs etc., and the production that is obtained therefrom. Generally speaking, if the main assemblies and components of the machine keep on being replaced at periodical intervals, and also if such inputs by way of additional investments give a residual life in operation commensurate with this investment, the user continues to employ the machines on the job. The Rehabilitation and Reclamation Organisation of Ministry of Labour, Employment and Rehabilitation, has in fact, thought it prudent to continue with the use of the old machines in preference to new machines as the resultant cost of the work done with then old machines is cheaper compared to the cost of the work that may be generally done by latest models of the new machines in the market. This is inspite of the growing cost of repairs to the machine.

8.3.7.2 *Case study*

In examining the issue regarding economic life of equipment and the maintenance and repair cost of machines, for illustrating the 'Life' in use of machines, the Committee have come across one example at Neyveli Lignite Corporation, where inspite of Caterpillar D—8 Tractors having initially worked for 15000 to 20000 hrs. on the job, were subjected to major repair and overhaul in order to sustain these machines in use for further spans of life. Normally, according to the schedules previously laid down for life of Crawler Tractors, these machines would have been discarded when these had clocked 10000 to 12000 hrs. of operation. However, inspite of rigorous working conditions as obtaining on the Neyveli Lignite Corporation job, the user could obtain useful service from the machines upto 15000 to 20000 hrs. of their operation and yet they decided on further repair and overhaul of machines.

The work of repair and overhaul was assigned to a private agency at a cost of Rs. 3,05,000 a machine approximately. The major items of repair to be done to the machine included replacement of certain parts and reconditioning of the others. A list of major parts replaced is given below. From the data received in this connection, it is observed that it involved 1100 man-hours of skilled labour and 400 man-hours of unskilled labour to thoroughly repair and overhaul each machine. The agency doing this work expects that the machines would perform well on the job for 10000 to 12000 hrs. atleast with additional repair costs as may be normally expected to be incurred on new machines of this class and category.

Hence, when these machines are finally discarded, these would have worked an average of 25000 hrs. approximately. While there is no doubt that a judicious decision for repair and overhaul of such machines, which have been in use for long periods of operation upto 15000 hrs. to 20000 hrs., would include consideration of the replacement costs of the machine (at present day market value of identical machine—in this case an indigenous product) and the cost of repairs involved, the main point that gets highlighted is that we can continue to use a machine as long as it is considered economical in operation, maintenance and repairs.

Major Parts replaced.

Diesel Engine

Water Pump.
Lub. oil Pump
Fuel transfer pump
Fuel injection pump
Turbocharger.

Starting Engine.

Carburettor
Magneto
Oil pump
Clutch group.

Electrical system

Generator
Starter
Regulator.

Flywheel clutch

Complete group.

Transmission

Oil pump assembly.

Final drive.

Oil pump assembly

Hydraulic system

Hydraulic steering pump assembly.

Undercarriage.

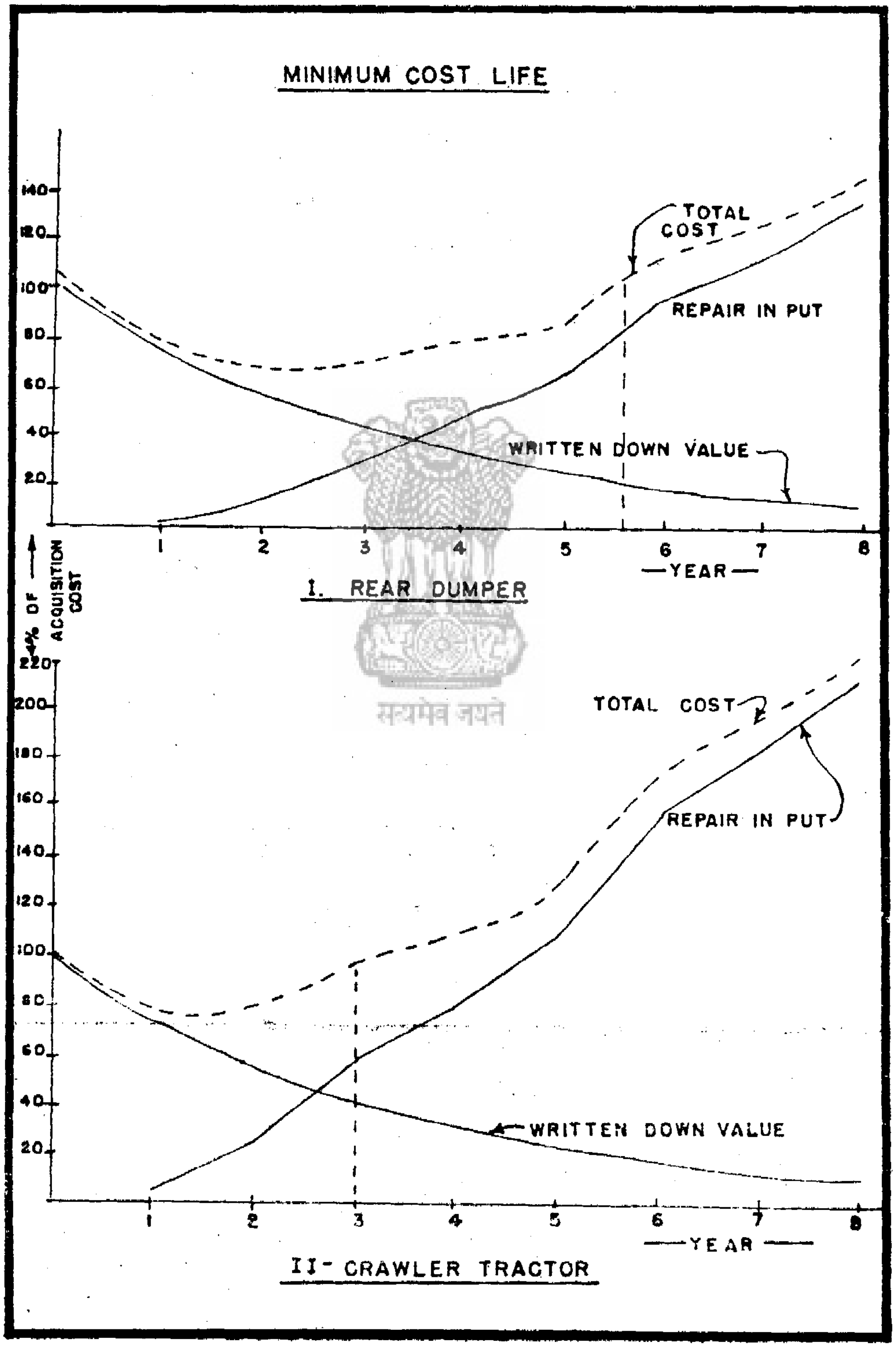
Track rollers
Carrier rollers
Link assembly.

8.3.7.3 *Life as adopted by various users*

Major equipment users have rendered information regarding the life they have adopted for various categories of equipment in use with them. The table showing the lives as adopted is given at Appendix 8.3. From the information tabulated in the appendix it can be seen that there is a wide variation from user to user, in the life of the same category of equipment. While most of the users have reckoned lives as per the recommendations of the earlier C.P.M. Committee, some of the users have revised the lives as per their experience with the machines. In most of such cases, the lives have received an upward revision. To quote an example, in a project, the life of Tractors initially reckoned at 10000 hrs., was revised upwards to 12000 hrs., 16000 hrs., and still revised to 18000 hrs. to 20000 hrs., as the machines could still be profitably used on the job.

8.3.7.4 *Graphical representation*

To illustrate the economic life as defined in para 8.3.6.5 graphically taking into account the concrete examples and using data as received from different users of equipment, examples have been worked out and graphs drawn. The resultant shape of the graphs are given below: —



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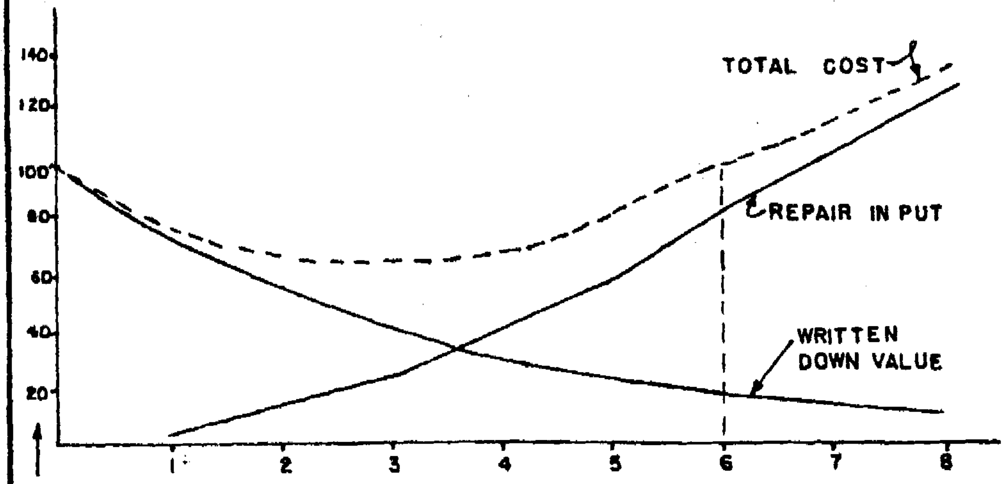
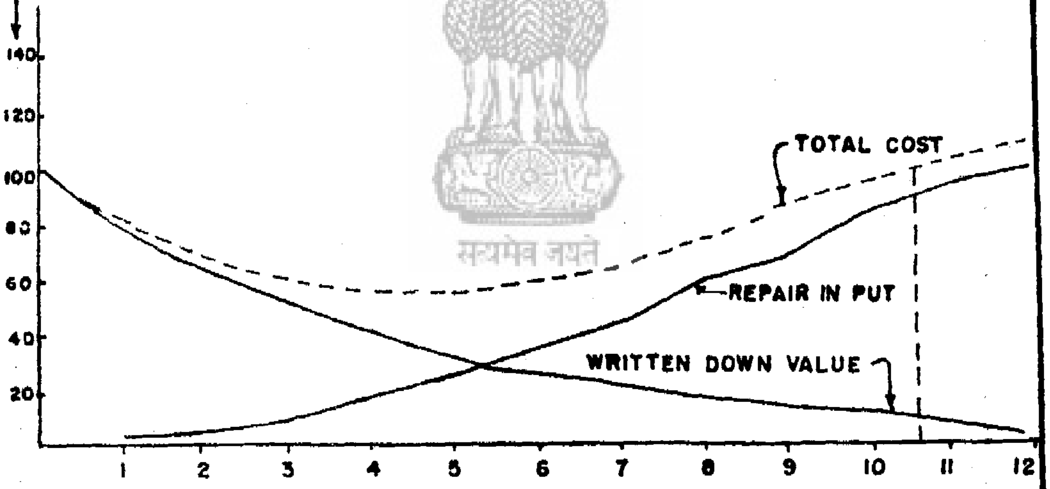


III CRAWLER TRACTOR (EXCLUDING TRACK)



IV. EXCAVATORS 2.5 TO 6 C.YDS.

Graph I relates to the case of Rear Dumpers. In this case, the depreciation cost has been reckoned on Declining Balance Method at 25% depreciation (corresponding to 2 shifts operation) of written down value each year, while the repair costs are on actuals basis, computed from the actual figures of annual expenditure rendered by various users.

This graph indicates a point where the curve giving the summation of residual value and repair costs crosses the horizontal line of 100% investment. If the replacement cost of a machine remains the same as the purchase cost of the original machine, the economic life may be taken as the number of years corresponding to this crossing point.

However, in actual practice the purchase price of an equipment of the same specification has an increasing trend in course of time and the increase could easily be of the order of 6 to 7% every year. If this factor is taken into consideration the replacement cost of a machine in the course of 7 to 8 years would be about 140 to 150% of the original equipment cost. Therefore, instead of looking at the intersection point of the curve and the horizontal line of 100% investment, one has to seek the intersection point of the curve and a sloping line going upwards from 100% investment at the initial year to 140 to 150% investment at the 7th or 8th year. If this is done the economic life will increase from 5 to 6 years to about 7 to 8 years. For our purposes the economic life may be judged by such reckoning.

Similar graphical representation in relation to Tractors (Graph II) however, leads to a little anamolous position, in as much as, the economic life point, in relation to 100% of investment cost occurs at the end of 3 years' life of the machine. In this case, the repair costs relating to the Track Group and Undercarriage items make the major portion of the repair expenditure on the machine. If the Crawler Tractor is to be equated to a pneumatic tyred equipment, the cost of repairs to the Track components may have to be treated like the cost of repairs/replacement of tyres on a pneumatic tyred machine. If that is done, the curve relating to Crawler Tractors (Graph III) would be similar to the one for Dumpers and the economic life point would arise in the 5th to 6th years of work when double shift work is involved. In respect of the item of Excavators (Graph IV) the economic life point would go beyond 5th/6th year of service life of equipment and may touch 10/11 years service life.

Above is only a graphical representation of a possible method to be followed for determining the economic cost life of a machine. However, in actual practice, this is a matter of close examination and study of the data recorded in relation to given items of equipment year after year and cumulatively over the period under consideration.

It may be stated that the determination of economic life figures for such equipment can be determined precisely only in relation to such jobs where the equipment is to continue working time after time, and not in relation to time-bound programmes as in the case of the Irrigation and Power Projects. The data so collected in relation to Irrigation and Power Projects can at best be detailed and examined for comparative economics of different makes and models of equipment in the same category under given conditions. This can lead the prospective users of such equipment elsewhere to make more precise estimates of cost of work with given items of equipment of different makes in the same category.

8.3.8 *Conclusion*

Whatever may be the physical life obtained by various users, one cannot divest from consideration in this context the physical deterioration of the machines to the point of its being physically unable to produce the profit or break even the economy in relation to investment costs. Hence, there would certainly be some physical limitations which may render the equipment useless for any further use on a given job. It is this consideration related to experience in the use of particular items of equipment under given job conditions which helps in defining the physical life of the machines.

Granting that the input by way of repairs would continue to be made in restoring the physical impairment of the machine due to ageing, given items of machines may be kept in use with profit for a given period of time in years. The work pattern and the intensity of use of machine—whether in single shift or multiple shift and the severity of the job conditions, determine the extent of usage of the machines time-wise.

Keeping in view the assessment as above, based on sample analysis of the information received, it can be generally stated that for an average piece of earthmoving machine (barring a few exceptional cases of electric powered excavators), the average figure of service life would be below 20000 hrs., corresponding to a period of 8 to 10 years of operation. Without getting into the basic exercise for determining the economic life of equipment considering all its aspects, the figures of life in years and expected hours of work have been tabled out in the statement at Appendix 8.4. This table further indicates the figures of percentage to account for depreciation, the residual value and the repair cost during life time for accounting purposes.

It may also be necessary to indicate that under certain conditions which may be very severe (machines working on high altitudes and hilly terrain, where road making etc. is the main job to be done by such machines) the useful life (to give the required degree of reliability) of equipment in number of years may be scaled down; but all the same, this will be a predetermined factor before the commencement of the work. The main idea is to write-off the part of the capital cost (capital cost minus salvage value) of the equipment over a given number of years of life of machine by any method of depreciation, as all methods of depreciation amount to writing off the total cost of equipment over a given period. The work being done by Border Roads Organisation would fall in this category. One of the primary considerations that may prevail in such a thinking of adopting a predetermined specified figure of useful life for the machine under such conditions would be, to assure better reliability of machines under such difficult condition of work. In such a case, it will amount to discarding the equipment somewhat in advance of the expiry of the service life in years; but in that event, the residual value of the machine would be more than the normal 10% figure. The discard point in the life of the machine and the residual value thereof, would normally get appropriately co-related, in the table showing life at a particular time and the corresponding depreciated value.

The recommendations for stipulating a fixed schedule of life of machines for replacement purposes would be only for furnishing tentative guidelines and not for laying a rigid rule to discard a machine when the operational hours cross a certain figure already laid down in the table prepared for the purpose. The user must be guided by the record of costs maintained by him during the life of the machine in use.

8.4 Major Repair and Field Repair Charges over the last 10 Years, in respect of Various Items of Equipment in terms of (1) Spare Parts and (2) Labour.

8.4.1 *Elements of Repair Cost*

Continued use of equipment results in physical deterioration of the moving components and parts in a machine. This results in physical impairment which further results in reduced efficiency in operation of a machine. Unless timely action is taken to seize the rate of wear on components, through timely repairs, or for a complete assembly through timely replacement of components, the machine may have to be discarded when it has worked for a small fraction of its expected service life. Such repairs become necessary in part during the course of operation of equipment, and these are then termed as 'Running repairs', or 'Field repairs'. At periodical intervals in the operational service of the machine, however, more intensive repairs become necessary where the machine has to be stopped and taken to a service shop, or repair shop, and dismantled for a thorough check up of the assemblies, sub-assemblies, components and parts of the machine. The repairs resulting from such periodic checkups at long intervals take the shape of "Major Repairs". The periods at which the running repairs and the major repairs become necessary, are determined by exercising preventive maintenance inspections.

According to the system in vogue at present, the users of equipment classify the running repairs as "Field repairs", "Minor repairs" etc., while the repairs carried out at periodic intervals when the machine is laid off from the work are termed as "Major Repairs", or "Overhauls."

Normally, it is very difficult to lay down a precise set of criteria for a classification of the repairs as "Minor Repairs", or "Major Repairs". Occasionally, in the interest of sustaining continuous production on the job with the machines, it is customary to replace some of the components and assemblies on a machine by new assemblies and components or renovated/reconditioned assemblies and components etc. Eventhough the cost of such replacements is substantial in monetary terms, the fact that the downtime of the machine for such complete assembly replacements is much lesser than the time normally involved in overhauling of machine, some of the users of equipment classify such repairs as "Running Repairs", or 'field Repairs'. Cases have come to the notice of the Committee where the "Running Repairs" Charges far exceed the "Major Repair Charges" for given items of equipment. From standpoint of economics of equipment, and the history of performance of the machine, classifying the repairs as "Running Repairs" or "Field Repairs" and "Major Repairs", is misleading. It is, therefore, the considered opinion of the Committee to classify the repair costs under one head, not making a distinction between the running repairs and major repairs.

The two major elements of cost involved in repair costs are:

1. Cost of spare parts used for repairs and
2. the cost of labour.

The cost of spare parts makes the bigger part of the total expenditure on repairs.

8.4.2 *Composition of Repair Charges as Received from various Projects*

It has not been possible for the Committee to get data relating to repair charges over the last 10 years in respect of various items of equipment in terms of: (1) spare parts, and (2) labour. Even to compile such information for a period of five years has been problematic; the main reason being that the records on the extent of repairs are not kept properly by the users of equipment and are inadequate.

Attempt was made to collect the information from only 34 major users of construction equipment in the country. Useful data could only be received from about 12 major users. The data, as received, has been compiled and given in Appendix 8.5.

In some of the cases, it was difficult to differentiate between the expenditure on spare parts and labour, for want of proper records in this connection. The figures given in the Appendix indicate the expenditure on spare parts and labour combined for repairs to groups of machines category-wise. The year-wise expenditure figures indicate the cumulative expenditure as a percentage of the initial purchase cost of the machine. Sampling of the information, as obtained, has been done for graphical representation thereof in relation to principal categories of machines. The graphs, based on repair costs figures as actually rendered by various users, in relation to particular items of equipment, are at Appendix 8.6.

Bar Charts have also been drawn to reflect the expenditure at different slabs of working life of equipent—at 2000 hrs. intervals, for the same item of equipment used on different projects. These charts show a wide variation in the expenditure under different slabs which could be attributed to variation in the job conditions and also to variation in the management efficiency.

8.4.3 *Norms for repair cost*

Almost for all items of equipment the repair cost if plotted against operational hours will take the shape of saw tooth pattern of a repetitive cycle with repair cost going up with each repetition.

Let us take the case of a crawler tractor. In practice, the crawler tractor, as a machine, would undergo major repairs, or a complete overhaul after the first 3500 hrs. of its working. During that period, the repair work would commence with minor adjustments in the track-group and in the diesel engine, whereafter, till the wear and tear on track-group components reach the permissible limits, the track-components are rebuilt and re-used on the same machine, or another machine. After the installation of the rebuilt components, these components give a life of about 50% of the new components/parts, whereafter, these can be discarded and replaced by new components. Once the new components are fitted on the machine, the cycle repeats itself with regard to the functional repairs to be carried out to these components on the machines, though in this instance, after the first replacement of components by new ones, the total cycle-time in the next replacement may be somewhat shorter—say 80% of the first cycle time for replacement. Thus, the repetitive repair costs take the shape of a repetitiev cycle.

Based on the consideration as above, relative to the repairs on the track-group components of a crawler tractor, the Committee have considered it necessary to assess or evaluate the repair costs of a given item of equipment in terms of groups/systems of which the machine is comprised. As an example, a rear dumper can be broken up into 4 groups of components: —

1. The power unit or diesel engine.
2. The clutch and the transmission, or in case of power-shift-transmission, the torque converter and the power shift transmission.
3. The final drive.
4. The wheels together with braking system.

The cyclic order of repairs on each one of these groups/systems on the machine, both in terms of cycle-time and the value of repair costs during that cycle-time, can be assessed and the sum total of repairs properly tabulated commensurate with the operation hours, relative to each cycle. Further tabulation can be made to indicate the repair costs for progressive operational time intervals of 2000 hours, 4000 hours, 6000 hours (onwards with intervals of 2000 hours each) etc. This would give an indication of the spare parts consumption for repairs at given intervals.

The above example and the break-up of the machine into groups of components, can find extension in its application to any machine where the group may be of the same nature or slightly different, depending upon the type and category of machines in question. For instance, in an electrically operated power shovel, the groups would be slightly different, depending upon the type of electrical system used and the particular mechanical systems on that machine which are far different in nature when compared to a rear dumper, a crawler tractor, or a grader etc. The basic way of analysing the position, however, remains the same.

Integrating the repair cost figures relative to the groups/systems of the machines, as indicated above, in further relation to the data received by the Committee from various users of equipment corresponding to particular items and categories of machines and information so tabulated graphically, a summary statement has been prepared in relation to five major categories of machines to indicate the likely expenditure on repair costs on, (1) crawler tractors; (2) rear dumpers, (3) motorised scrapers (4) excavators (diesel and electric); and (5) front-end loaders (wheeled). These norms are tabulated in Appendix 8.7.

It may be stated here that this tabulation at Appendix 8.7 is to furnish only a guideline so that scaling for provision of spare parts can be done on estimated basis by individual users of equipment, with the larger objective of keeping the stocks of spare parts to the minimum possible limits in due relationship to lead time for procurement and the scale of consumption of parts at different stages of service life of machines. Ultimately, the experience of the users of equipment itself would be the main guiding factor in drawing up properly and more precisely a scale of provision of spare parts at different stages of service life of particular items of machines working with them. The latter case would particularly relate to such users of equipment as are engaged on production work—mainly the mining sector. In relation to the equipment in use with the Irrigation and Power Projects, compilation of such data would be more from the point of view of benefit and guidance to the future users of equipment for better precision in estimating the provision to be made in the project estimates on account of cost of spare parts for given items of equipment required to do the work in a time-bound programme.

In the process of evolving norms for provision of repair expenditure at different stages of service life of the machines, some weightage has also necessarily to be given to the degree of severity of the job conditions where the machines are employed. The tables of norms, as prescribed in Appendix 8.7 reflect work with machines under average or medium conditions. For the purpose of relating this to the actual job conditions obtaining under given situations, a separate table indicating the multiplication factors of equipment cost has been evolved and the same is given at Appendix 8.8. This table defines repair provision during the life time for "Excellent", "Average" and "Severe" job conditions. This is also further related to the intensity of use of equipment according to established work patterns—single shift or multi-shift operation of machines.

The exact significance of classification of conditions as "Excellent", "Average" and "Severe" is further explained in Appendix 8.9 where, according to the duty application of individual items of machines, the particular areas which would be classified under one or the other job condition, are briefly described.

8.4.3 *Scaling of Spare Parts*

In the previous Report of the Construction Plant and Machinery Committee (1954), it was indicated that the requirement of spare parts would take the following shape at different stages of life of the machine:

1st Stage	10%
2nd Stage	15%
3rd Stage	25%
4th Stage	30%
5th or last Stage . . .	20%

The base for this percentage was the total provision for spare parts during the life-time of a machine.

The present pattern emerging from the graphs drawn on actual consumption basis, does not largely contribute to scaling as above. This is rightly so because of the reason that after every major repair and overhaul of machines, the maintenance/repair expenditure gets reduced until the time of next major repair and overhaul. The resultant pattern of cost of repairs to equipment takes a "saw tooth pattern". In order, however, to indicate the expenditure over each year of the service life of equipment or over each slab of its 2000 working hours, the tables of norms prepared, indicate cumulative total of the provision of repair cost corresponding to particular time slabs in the service age of the machines. This has to be particularly kept in mind if the total reserve for provision of spare parts is to be properly evaluated. It must however, be particularly mentioned that the purchases of spare parts would have to be made commensurate with actual needs based on the pattern of consumption and the lead time for procurement as involved.

8.4.4 *Labour Cost*

In relation to the element of cost of labour involved in repairs, the figures as compiled, based on actual information received from some of the users of equipment, indicate a large amount of divergence. The labour charges expressed in terms of cost of spare parts, vary from 7% to 30%. The Committee considers that the labour charges may be fairly estimated at 10% to 15% of the cost of spare parts.

8.4.5 *Estimation of Repair Cost*

In order to reflect more precisely and practically the basis of estimation of repair costs of equipment in terms of labour costs, the Committee also took up with the users of equipment, the matter regarding 'man-hours' involved in repair and overhaul of different machine/assemblies/components of machines of different categories. The information so compiled, is given at Appendix 8.10. The man-hours involved in repairs and the average amount of expenditure on repairs used in the process of such repair and overhaul, when co-related one to the other, would also bring the figure of expenditure on labour to about 10% to 15% of the cost of spare parts.

The Committee have also considered to make assessment of the average figures of man-hours involved in rebuilding of components—specially, track components of crawler tractors. The information is given in Appendix 8.11.

The estimated figures of man-hours involved by way of labour for overhaul and reclamation of components work will help the users of equipment to get some of the serviceable parts reclaimed by some of the established agencies. In relation to track-components of Crawler Tractors, some of the Government Departments have established necessary facilities to do this work with the help of specialised equipment installed for the purpose. Some of the dealers/suppliers of equipment have also set up such facilities in certain areas of the country. Since such reclamation process entails good deal of economy through conservation of old parts, (with 25% of the cost of spare parts as expenditure on reclamation, one can easily get 50% of life of the new parts/components), the users of equipment should make it a habit to resort to such conservation programme of parts rather than keep replacing the old parts by new ones when the old ones have been run to destruction. This matter has been dealt with in more details in the Chapter on "Maintenance procedures" as a part of the preventive maintenance work.

8.4.6 *Norms of Life and Repair Provision of Tyres*

In relation to the subject of norms for life of equipment and the expenditure on spare parts and labour for its repairs, it has also to be mentioned that there are certain items of parts used in the process of maintenance and repair of equipment which are treated individually and separately from the integrated machine units for purposes of accounting of their repair costs or even depreciation. By this, the reference is to items like tyres and conveyor belts etc.

The item of tyres, in relation to mobile equipment, is not included for evaluating the cost of equipment. The cost of tyres is depreciated separately and included in the hourly use rate of equipment, wherever such estimated use rate charges are adopted for accounting purposes. A separate figure of life of tyres is decided upon by estimation consistent with the load to be carried, the average speed of vehicles, the type of surface to be negotiated and above all the rolling resistance of the surface over which it plies.

8.4.6.1 *Life of tyres*

It is customary to work out the estimated life of such tyres based on a number of factors as given below.

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Factors in Earthmover Tyre Life

Group I—*Maintenance includes in flation*

Excellent	1.1
Average	1.0
Poor	0.7
Very bad	0.4

Group II — *Maximum speeds*

15 KM per hour	1.2
30 KM per hour	1.0
45 KM per hour	0.8
60 KM per hour	0.5

Group III — *Curves*

None	1.1
Moderate	1.0
Severe, single wheels	0.8
Severe, dual wheels	0.7
Severe, tandem wheels	0.6

Group IV — *Surface*

Show, packed, no road exposed Earth	3.0
Hard packed earth	1.0
Soft earth or sand matinained	1.0
Gravel road, well maintained	0.9
Soft, earth, some rock	0.8
Mud, ordinary	0.8
Gravel road, poorly maintained	0.7
Mud, abrasive or with rock	0.5

Blasted rock

Soft coal	0.9
Soft shale or limestone	0.7
Granite, gneiss, trap, basalt, hard shale or limestone	0.6
Slate or schist	0.4
Lavae, hard surface	0.3
Obsidian, volcanic glass, flint	0.1

Black top

Clean, wet	1.4
Cold weather	1.2
Hot weather, 75 to 100°F	0.8
Very hot, over 100°F	0.5

Group V— *Loads*

Recommended by Tyre and Rim Assn. Full Load	1.0
50% underload	1.2
20% underload	1.1
10% Overload	1.0
20% Overload	0.8
40% Overload	0.5

Group VI— *Wheel position*

Trailing	1.0
Front (non-driving)	0.9
Driving	
Rear dump	0.8
Rear dump tandem	0.7
Bottom dump	0.7
Scraper, self-propelled	0.6

Group VII—*Grades, Drive tyree only*

Level Firm Surface	1.9
6% maximum	0.9
10% maximum	0.8
15% maximum	0.7
25% maximum	0.4
Loose or slippery surface	
6% maximum	0.6
10% maximum	0.6
15% maximum	0.4

Group VIII— *Miscellaneous conditions and combinations*

Favourable, or counteracting	1.5
None	1.0
Unfavourable	0.8
Very unfavourable	0.6

Following is an example showing how the tyre life would be worked out in relation to particular factors chosen from the above table, as applicable for a particular job, where the tyred equipment may be in use:—

Optimum tyre life 6000 hrs. or 100000 KM.

Example.

To determine the tyre life with the following condition of working:

I.	Maintenance, average—	1.0
II.	Speed. 45 KM (maximum)	0.8
III.	Curves, moderate	1.0
IV.	Surface, soft earth, some rock	0.8
V.	Load, 20% overload	0.8
VI.	Wheel position, Driving Bottom Dump	0.7
VII.	Grades, 10% maximum firm surface	0.8
VIII.	Misc. condition, none	1.0

Tyre Life— (6000 hrs. or 100000 KM) ×1.0×0.8×1.0×
0.8×0.8×0.7×0.8×1.0
=1720 hrs.
or 29000 KM.

8.4.6.2 *Data as collected on life of tyres*

The Committee attempted to collect necessary data from different users regarding figures of hours of tyre life actually obtained on certain jobs. Unfortunately, it has not been possible to present a consolidated information in this respect. This is mainly due to inadequate records maintained by the users of equipment regarding tyre life etc. All the same, in relation to the very few projects, from whom data on tyre life could be obtained, the summary given in Appendix 8.12 furnishes the relevant information.

8.4.6.3 *Choice of tyres for increased life*

With the progressive development in design of tyres to suit different working conditions and job applications, the heavy duty tyres for earthmoving machines and other similar heavy machines afford the promise of longer lives in use. The only thing a prospective purchaser of equipment is to be judicious about, is to make an appropriate choice of the best combination of tread design relevant to particular job conditions/applications, extra wear resistant features, if any possible, to be included in the design, the speeds to be negotiated and the ambient temperature conditions under which these would be used. Lot of research has been made by the original equipment manufacturers with regard to the type and size of the tyres to be used on particular units of machines in specific context of the speeds inbuilt into the units and the load to be carried thereby. Extensive study has also been made to withstand the heat generation aspect in using such equipment on long haul distances over rutted roads and over black-top roads. The abrasive nature of certain materials like Iron Ore etc., has also been taken into account to manufacture tyres which would not wear out quickly and would cost the least per ton of payload carried by the machines. Such attention is necessary in selection of tyres for given items of equipment, as is basically necessary for making initial choice of equipment of a certain design suitable for the given job.

8.4.6.4 *Repair provision for tyres*

The repair costs of tyres are generally provided for in the estimates of hourly ownership and operating cost of equipment at 15% of the cost of tyres over the life-time of the tyres.

8.5 **Summary of observations and recommendations**

Scanty foreign exchange resources and a late start in indigenous manufacture of construction plant and equipment in the country, resulted in increased dependence for import of equipment—from whereas countries who could offer aid loans/credits. This afforded restrictive choice of equipment in various categories. The resultant lack of standardisation brought in its wake a rather unhealthy effect on economy in construction/production costs. Except for the standard items of equipment of reputed makes, the standard of performance of the imported equipment has not come up to expected levels. To some extent, any developing country has to face such situations until even a partial degree of self-reliance and self-sufficiency is built up through development of local resources.

Such imports from restricted sources, lasting for comparatively shorter periods, could not be properly supported, regarding after-sales-service, by the foreign principals/agents/dealers/distributors in India. Some of them attempted to organise themselves for such service only after being declared as the accredited agents/dealers/distributors. Consequently, the initial low availability of some of these non-standard items of equipment got further reduced. The utilisation of such equipment has been therefore, poor.

Eventhough, in absence of proper record keeping on part of the users of the equipment regarding technical performance, cost evaluation and operational data, it is difficult to judge the economic life figures of machines, the reported figures of utilisation of equipment from the date of first commissioning of machines upto November 1970, indicate that the machines are kept in use as long as these can be made to work. Similar or identical machines have clocked 5000 to 7000 hrs. in the course of 7 to 10 years of their operation with some users, while with others, the corresponding figures of life have been intimated to be 20000 hrs. and above in a similar period of time, or a little longer. Accepting the principle that intensity of use of equipment and the input by way of maintenance and repairs into the machines are the two main factors based on which schedules for working hours in life of equipment can be defined, recommended figures of life of machines in this connection, have been arrived at.

Information regarding major repairs, and field repair costs, including spare parts and labour costs, have been made available by a few users of equipment only. Based on a broad spectrum of analysis of the information so received, guidelines have been established indicating scale of provision for spare parts and labour costs. These have been further related to factors of severity of job conditions. The labour costs are reckoned at 10% to 15% of the cost of spare parts. The tables showing provision of repair charges can, therefore, be conveniently used for scaling out the consumption of spare parts, corresponding to a span of 2000 to 25000 hrs. operation of the life of the machines.

In conclusion, it can be stated that for technical evaluation of performance of equipment, cost evaluation, cost effectiveness, defect analysis, preventive maintenance methods of improvement etc., it is essential that the users of equipment maintain a proper record of, (i) performance of machines; (ii) the expenditure on operation, maintenance and repair; and (iii) details of breakdowns, defects, adjustments, modifications etc., etc. A proper review of these records for given periods of time and on cumulative basis year after year, would present a clear picture to the equipment owner regarding economics of use of the machines. This would also help in introducing methods for improvement of performance in the methods of use, in carrying out any technical modifications in different systems of the machines; and in carrying out repairs to the required extent for optimum utilisation and production at least cost.

Recommendations

1. Bulk purchase of equipment of new makes should be resorted to only after (a) proper tests and trials are conducted initially on these machines by importing a small quantity into the country; and (b) the technical modifications on the design and construction features that may be indicated by the tests are properly carried out.

2. The research and development organisation of the manufacturers of indigenous equipment, besides making research for improvements in the design/systems of the machines based on experience of the equipment users in the field, should also make a continuous advancement in the technical front to make the machines more productive at lesser maintenance and repair costs.

3. Unless the items of equipment selected for manufacture are those, which have been previously in use in the country and whose performance has been found to be satisfactory, a prototype should be imported for rigorous tests and trials for technically evaluating its standard of performance before it is accepted for manufacture in the country. Such selection of equipment for indigenous manufacture may be done in association with the recommended Standing Committee for Equipment Planning.

4. Determination of a schedule for life of equipment should not be primarily related to the consideration for accounting of depreciation costs. Instead it should be related to the subject of Equipment Economics. The cumulative costs of depreciation, maintenance and repairs over the service life of the machine, should be the deciding factor. For this purpose, clear records be maintained regarding cost of maintenance and repairs.

5. Repair costs should be classified under one head only without making a distinction between field repairs/running repairs/minor repairs and major repairs.

6. To gauge more accurately the expected costs of repairs to the machine, the machine should be broken up into systems/components —power unit, clutch, transmission, final drive, hydraulic system, electrical system, braking system and wheels/crawler tracks, etc. The anticipated intensity of wear and tear on parts, in individual components/systems, can be sized up better by such analysis.

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CHAPTER 9

HIRE CHARGES OF EQUIPMENT

9.1 Need for Hiring out Equipment

The rapid strides made by the construction industry in undertaking large scale construction work according to defined time bound programmes has made it necessary that industry should keep pace with the modern methods and techniques of construction. This has further necessitated intensive use of complex and sophisticated equipment on the job. Such equipment being very expensive in terms of initial acquisition cost, it becomes necessary to evaluate precisely as to how far would it be prudent to purchase the required items of equipment for given jobs under execution specially when these are to last for short durations. Most often, recourse is taken to assign such jobs of short duration to contractual agencies, unless the required equipment can be made readily available for departmental use on that job on diversion from some other jobs under charge of the same project authority or the State where the work is to be executed. Further more, the construction work, besides including the items of work where equipment is to be departmentally used, also involves other items of work generally let out on contract basis to the contractors. Some of these items may also, however, require the use of some machines. In such an event, it becomes essential that, if a contractor does not have the required machines as his own property and if the machines are available with the project owning authority, or can be arranged to be made available by him to the contractor, the machines are hired out to the contractor.

Yet in a few other cases, the contract bids are called for clearly based on the understanding that departmental machines will be hired out to the contractors for doing a given item of work within a period of time, which may extent over 2 to 3 years or even longer. Some times, it also happens that inspite of the contractor offering to use his own equipment on the job, due to unforeseen breakdowns of/accidents to his machines, he has to obtain on rental basis some items of machines from the project authorities, if the work is to be completed according to a pre-defined schedule of time.

9.2 Need for Evaluating Hire Charges

9.2.1 *Competitive Bidding by Contractors*

Under such conditions to attract competitive bidding from competent contractors, it becomes necessary for the individual prospective bidders to know the equipment costs in relation to the time for which these would be required to be used on the particular work under bidding. Knowledge of such costs will provide information for the intelligent bidding. These costs would get related to prices for performing a unit of work to be done under contract. The price of the unit of work, as part of the total work to be done will be determined by the bidder by his assessment of such production in a unit of time. As an example, the contractor bidding for excavation work would determine the hourly production by a given combination of machines and the corresponding figure of cost of owning and operating that equipment during the same unit of time viz., an hour.

9.2.2 *Assessment of equipment cost by owner*

The owner of equipment on the other hand, would be more aptly concerned with the ownership cost of the equipment, annual costs on construction equipment taking into account the cost items, such as depreciation, interest and insurance, which accrue even when the equipment is not being operated. Further more, he also considers the elements of cost chargeable to an individual unit of equipment for servicing, maintenance and repairs including repair parts and repair labour. A portion of these costs may not look visibly expendable at certain stages of life of the machine, when it is let out to contractors on rental basis, specially when the equipment is new, but the physical wear and tear of the machine in use may cause unnecessary expense on this account to arise in the subsequent period after the machine has been received back from the contractor. To account for such a contingency, the equipment owner has to so distribute the elements of such costs over the life of the machine that through uniformly levied or pro-rated apportioning of expenditure as an hourly charge, he is assured of recovering the total amount of expense he might incur during the service life of the machine.

Such assessment/evaluation, also helps the the owner of equipment (A Government Department) to judge clearly if the rates quoted by a contractor, for an item of work on which the rented equipment will be used, are reasonable.

Accordingly, therefore, the equipment owner must also know his equipment costs not only on hourly and on annual basis, but for the entire span of estimated life of equipment in question.

9.3 Concept of Hourly Ownership & Operating Cost.

The equipment owner evaluates such equipment costs on annual basis mainly for the convenience of annual accounting of expenditure according to financial years, as also to meet, in some cases, the provisions of the financial rules in relation to Income-Tax Law etc. When all the annual equipment expense elements are so grouped and averaged for a machine or for a group of like equipment units by an hour, the resultant figure of cost is termed as "Hourly Ownership and Operating Costs."

9.3.1 *Elements*

The elements of costs as such are generally classified as:

1. Depreciation.
2. Direct Costs.
3. Indirect Costs.

9.3.2 *Depreciation*

The item of depreciation is generally used to signify the loss in value sustained by a unit of equipment due to usage or elapsed time. The depreciation charge may be based on complete amortisation of the original equipment costs, or by providing for some salvage value. This would be further dealt with separately under item "Ownership Costs."

9.3.3 *Direct Cost*

Direct Costs are those chargeable to an individual unit of equipment for operation, maintenance and repair, and includes such items as fuel, lubricants, repair parts and repair labour.

9.3.4 *Indirect Costs*

Indirect Costs include a broad category of expenses which are incurred for the upkeep of the entire equipment and must be charged to an individual unit of equipment by some method of proration. Supervisory and Clerical salaries, travel expense, public utility services, maintenance of buildings, depreciation of shop equipment and office supplies are typical of indirect equipment costs. These may some times be classified as "Supervision and Overhead Charges."

9.4 Hourly Ownership & Operating Cost for Accounting Hire Charges

Another concept of classification of Ownership and Operating Costs involves grouping of elements of costs in a manner so that the owner of equipment can clearly visualise and assess the financial liability that has to accrue to him for keeping the equipment in good working condition.

9.4.1 *Ownership Expense*

The ownership expense in such a case, includes the elements of depreciation costs, interest charges on investment made and repair costs as well as any other taxes or storage and warehousing charges that may be incurred by him. In brief, this would cover the cost of maintaining the property/capital equipment to be hired out, so that the normal requirement of recovering the cost of equipment by the end of its economic life can be properly met with.

9.4.2 *Operating Expense*

The elements of costs incidental to running and maintenance of the machines—including operational labour, operational supplies, maintenance supplies (but without repairs due to normal wear and tear), and cost of any other sundry items used in the process, are listed under "Operating Costs". The details in this respect have been elaborated in Chapter 13.

9.4.3 *Proration of the Expenses*

Proration of annual ownership and operating costs on hourly basis in relation to particular items of machines to be let out on rental basis, then makes a part of the hourly hire charges of equipment.

The Indirect Costs or Supervision and Overhead Charges, similarly prorated on hourly basis, when integrated with hourly ownership and operating costs, make the figure of fire charges of equipment.

9.5 Existing System of Hire Charges

9.5.1 *Collection of data*

The Committee, in the course of their deliberations on this subject, have collected data from various Government Departments, Public Sector Undertakings and Project Authorities to verify details of the prevailing practice in assessment of rental rates or hire charges for equipment. The details as collected in this respect, are given in Appendix 9.1.

9.5.2 *Observation*

A study of the details given in that Appendix clearly reveals that there is no uniformity in the method of assessment of the basis elements of costs—ownership and operating cost, in the rate structure of hire charges adopted by various users of equipment. Some of the project authorities go by the stipulations in the State PWD Manual which defines the hire charges at a certain percentage figure of the market value of the machine per month. In other cases, the hire charges are worked out to include the elements of cost relating to ownership of equipment and running and maintenance of equipment. Overhead, supervision and establishment charges are also levied on different patterns suiting the convenience of the project authorities, or Government Departments.

9.6 Uniform Basis for Assessment of Hire Charges

In order to provide a *uniform basis* for assessment of the element of costs that should be included in the rate structure of hire charges for equipment, the following items would be important:—

1. Depreciation.
2. Interest Charges, on average annual investment.
3. Repair Costs.
4. Operational Labour Charges.
5. Cost of Fuel, Lubricants and greases.
6. Maintenance Labour cost.
7. Cost of miscellaneous/sundry items.
8. Overhead and supervision costs.

9.6.1 *Depreciation*

9.6.1.1 *Concept of Depreciation*

Depreciation is the loss in value of the machine or other property with time. It is determined from total cost, salvage value and economic life. Total cost is the sum of the purchase price, shipping and freight charges from place of purchase to purchaser's warehouse, costs of assembly and erection, and taxes, if any. The salvage value is the minimum scrap value that may be expected when the machine is completely discarded and disposed of. Economic life is determined conventionally as the number of hours in operation of the machine in its life time.

9.6.1.2 *Methods of computing depreciation*

Depreciation may be computed by Straight-line Method, Constant-ratio (The Declining Balance Method), Some-of-the-years-digit Method, or Service Outputs Method.

9.6.1.3 *Declining Balance Method unsuitable for accounting of hire charges*

A Contractor, in the event of owning his equipment for deployment on a given job, would account for all such costs by way of ownership and operating expenses of the machines, in the manner warranted by the Income-Tax Rules. He would, accordingly, have the choice of adopting a Declining Balance Method of depreciation, when the amount of depreciation of equipment to be accounted for year after year, in the progressive operational life of equipment, would vary from year to year. Hence, for hire charges purposes, this would not be too aptly suited for evaluating the element of depreciation cost.

9.6.1.4 *Depreciation for accounting of hire charges*

The Straight-line Method consists simply of dividing the total cost (Salvage value is not considered for equipment given on hire), by the estimated life of the machine. This probably is by far, the most commonly used method of computing depreciation, specially when simplicity of accounting alone is the main objective in view and keeping a separate set of books/accounts for individual machines is to be avoided. While in relation to equipment in use with Government Departments, the merits and demerits of different methods of depreciation will be dealt with separately in Chaupter 13 "Accounting for the ownership and operating cost per plant hour", for purposes of fixing a uniform procedure for hire charges of equipment, the Straight-line Method will be used.

9.6.1.5 *Fixation of minimum charges to safeguard against under-utilisation*

In relation to loaning of equipment on hire charges basis to contractors, certain specific situations have to be taken into consideration. If the hire charges are fixed on per hour basis, there is a chance of the machine being under-utilised by the contractor with the reasoning that the hire charges would be paid for the actual hours the machine will be in operation during the period of hire. In such a case, since the depreciation would continue to accrue to the owner of equipment during the idle period due to under-utilisation, to safeguard against such under-utilisation, it is considered to fix basic minimum charges for different periods of loan of equipment on hire charges as follows:—

1. Annual basis, corresponding to 2000 hrs. per year as a minimum charge.
2. Monthly basis, corresponding to 250 hrs. as a minimum charge.
3. Weekly basis, corresponding to 60 hrs. as a minimum charge; and
4. Daily basis, corresponding to 10 hrs. as a minimum charge.

9.6.1.6 *Safeguard against the burden of idle-time depreciation*

Further more, if a machine is given on rental basis for a period of one month, whereafter, the machine is returned to the storage yard and keeps idle for an assumed period of two months, whereafter again it is rented out to another contractor for a period of three months, the depreciation would continue to accrue to the owner of the equipment even during the idle-time period. Hence, with regard to the element of depreciation, certain safeguards have to be provided in the rate structure of hire charges, so that the owner of equipment does not have to bear the burden of the costs of depreciation for the long periods of idle time.

There are many conventional practices to provide for additional charges in the rate structure of hire charges to safeguard against such burdens of idle-time depreciation on the owner of the equipment. This has to be partially achieved by considering the life-span of equipment at a slightly lower figure than what is actually achieved and considered in the Chapter 13 "Accounting for Ownership and Operating Costs".

Further, the possibility of idle-time will be more in case of hiring out the equipment on hourly basis than the hiring on daily basis and in case of hiring out on daily basis than the hiring on weekly basis and so on. For this purpose, the rental rates for hiring out equipment on hourly basis, daily basis, weekly basis and monthly basis have to be assessed at certain higher figures than the rates for hiring out on yearly basis. The additional hire rates as would be charged on monthly, weekly, daily or hourly basis, would cover a part of the idle-time depreciation.

This classification of rental charges as above, will be referred to in a subsequent portion of this Chapter in relation to ownership expense charges in the hire charges.

9.6.2 *Interest Charges*

The interest charges are to be related to the average annual cost of equipment based on the life of equipment in number of years—the yearly life figures being obtained by dividing the total life hours of equipment by 2000 hrs. per year.

The average annual cost of equipment is determined as follows:—

$$\text{Capital cost of Equipment} \times \frac{n+1}{2n}$$

where 'n' is the number of years of life of a machine. The rate of interest per annum may be taken at prevalent figures at the time the equipment is given on hire charges basis.

9.6.3 *Repairs*

9.6.3.1 *Accounting of Repair Costs*

In general, repair costs constitute certain unknown factors in the equations of the rental cost and economic life. The repair costs keep increasing year after year with the progressive ageing of the machine. However, since these costs have a vital bearing on the economic life of a unit, these also have to be so accounted for that the owner of equipment does not sustain a loss even if the equipment is let out on hire charges basis to contractors for short periods. Here again, it is considered difficult to put a sliding scale for charging the element of cost of reapirs which may keep increasing as the age of the machine increases. The only possible way to simplify the method of evaluation of repair costs to be included in the rental charges would be to consider the overall span of life of the machine in number of hours, and determine the hourly charge by dividing the total repair costs for the life time by the total life hours.

9.6.3.2 *Scaling of Repair Cost*

The total repair costs for the life of a machine would, however, have to be scaled out properly, keeping in view, the type of activity to be performed by the machine, the job conditions and the situation where it will work and other considerations, as explained and defined in Chapter 8.

9.6.4 *Ownership Cost*

9.6.4.1 *Ownership Charges—relationship With rental basis*

Referring back to the conventional classification of periods for letting out equipment on rental basis to contractors, as referred to in paras 9.6.1 and 9.6.1.6 it may be indicated that if, in relation to a given item of machine loaned out on annual basis for a minimum of 2000 hrs., of work in a year, the hourly depreciation and interest charges are 'X', the corresponding figures for hourly rate of depreciation and interest expense for renting out equipment on monthly, weekly, daily and hourly basis would be as follows:—

Monthly basis . . .	1.2 X per hr.
Weekly basis . . .	1.4 X per hr.
Daily basis	1.6 X per hr.
Hourly basis	1.7 X per hr.

If 'Y' be the repair charges of equipment per hour, the ownership expenses for renting out equipment on different basis will be as follows:

Yearly basis	X+Y
Monthly basis . . .	1.2 X+Y
Weekly basis . . .	1.4 X+Y
Daily basis	1.6 X+Y
Hourly basis	1.7 X+Y

In case the equipment works for longer duration—more than the minimum hours referred to in para 9.6.1.6 preceding, the carge for additional hours would be on pro-rata basis at the rates mentioned for the corresponding periods.

9.6.4.2 *Evaluation of Ownership Cost*

The ownership cost per year can be evaluated from the following formula for determining the ownership element of the hire charges on yearly basis, monthly basis/weekly basis/ daily basis/hourly basis:

'C' be the Capital Cost of equipment in Rupees excluding cost of tyres, if any

'H' be the life of equipment in hours.

'n' be the number of years of life of equipment.

'i' be the Rate of Interest Charges per year.

'R' be the factor of cost of equipment as repair charges during the life time (including price escalation and obsolescence factor on cost of spare parts).

Ownership Cost per year

Depreciation per year . . $= \frac{C}{n}$

Interest Charges per year . $= \frac{C\,(n+1)}{2n} \times \frac{i}{100}$

Depreciation+Interest per year $= \frac{C}{n}\left\{1+\frac{(n+1)i}{200}\right\}$

Repair Charges per year . $= \frac{RC}{n}$

Ownership cost per year . $= \frac{C}{n}\left\{1+\frac{(n+1)i}{200}+R\right\}$

Ownership Cost per Hour

Depreciation+Interest per hour $= \frac{C}{H}\left\{1+\frac{(n+1)i}{200}\right\}$ ...X

Repair Charges per hour . $= \frac{RC}{H}$ .. ..Y

Ownership cost per hour $= \frac{C}{H}\left\{1+\frac{(n+1)i}{200}+R\right\}$..X+Y

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9.6.4.3 *Table*

A table indicating the life of equipment in hours/years, the rate of anual depreciation, the cost of repairs for average working condition inducing escalation and obsolescence factor on cost of spare parts and the figures of interest charges at 6% of average annual investment, corresponding to the figures of life in years of different items of machines, is given at Appendix 9.2. The total covers only 24 items of equipment which are generally let out on hire to contractors by the project authorities/owners of equipment.

Should there be any other items to be let out on hire charges, the broad outline of evaluation of different elements of ownership expense as given, may be adopted as guide line in working out the figures in relation to particular additional items of machines.

9.6.5.1 *General practice*

9.6.5.1 **General practice**

The other main element of cost in the rate structure of hire charges is the operational costs. These would bear a direct relationship to the number of hours of operational of machines in a given time except for the cost of operation and maintenance labour employed as such staff is paid on monthly basis irrespective of the number of hours a machine can work in a given year, or a month. It is a common practice to permit the contractor to incur expenditure on this account by himself if the machines are given to him on rental basis for long duration of time. If the departmental labour is operating the equipment and all supplies of fuel and lubricants and greases etc., are made by the department, this charge is included in the hire charges figures. This happens mainly when the equipment is given out on hire charges on hourly basis or daily basis and in some cases, even on monthly basis.

9.6.5.2 *Evaluation of operational cost*

It is also generally necessary to evaluate the cost of operation on hourly basis specially when the equipment is hired out on hourly, daily or monthly basis. In such a case, the elements of cost in operation (items 4 to 8 in para 9.6 above), have to be clearly assessed and summed up and then distributed over the figure of anticipated daily/monthly/yearly hours

The operating cost per hour can be evaluated from the following formula. This is for rough estimation purposes only.

F—be the fuel consumption per hour.

L—be the labour charges (Operation and maintenance per year).

T—be the cost of tyres in Rupees.

h—be the life of tyres in hours.

r—be the factor for repair charges to tyres as a cost of tyres.

n—be the life in number of years.

H—be the life in number of hours.

Operating Cost.

Fuel Charges per hour . . = F

Lubricant and sundry items per hour . . . . . = 0.33 F

Labour Cost per hr. . . = $\frac{L \times n}{H}$

Tyres, if any . . . = $\frac{T}{H} + rT$

$$\text{Total}: \quad F + 0.33\,F + \frac{Ln}{H} + \frac{T}{H} + \frac{rT}{h}$$

$$1.33F + \frac{Ln}{H} + \frac{T}{h}(1+r) \quad \ldots\ldots\ldots\ldots \quad Z$$

9.6.6 *Supervision and Overhead Charges*

9.6.6.1 *Evaluation*

To meet the expense of supervision, accounting and other contingencies arising in the presence of liaison between the equipment owner and the contractor, to whom the equipment is let out on hire, the expense on this account incurred by the equipment owner is to be evaluated in terms of an hourly charge by way of overhead expense. This may vary from work to work and from one situation to another, depending upon the size of fleet of machines let out on hire or the type of work spread on which the machines are employed. This can be generally evaluated by the equipment owner himself, but as a rough approximation, this may vary from 10% to 15% of the total hourly ownership and operating expenses. Provision for overhead charges must therefore, be always made in assessing the final rate of hire charges to be levied relative to items of equipment rented to contractors.

9.6.6.2 *Element of cost to be include*

The overhead charges would include the wages and other emoluments payable to the staff deputed for supervision and inspection etc. of the machines, as well as the other items of expenses generally incurred by the equipment owner in providing transport to such staff, the expense on account of residential accommodation, water supply, electricity charges, functional benefits, over-time payments etc.

9.6.7 *Integration of Ownership and Operational Costs on hourly basis*

Considering the elements of costs as above by way of ownership expense and operational expense of machines to be let out on hire, the following formula may be used for this purpose:

9.6.7.1 *Ownership Cost*

Depreciation and interest charges per hour $= \frac{C}{H}\left\{1+\frac{i(n+1)}{200}\right\}$ ...X

Repair Charges per hour $= \frac{RC}{H}$ .. ..Y

Ownership Cost per hour $= \frac{C}{H}\left\{1+\frac{i(n+1)}{200}+R\right\}$ X+Y

Substituting the figures of $H = 10{,}000$

$i = 6$

$n = 5$

$R = 1$

Ownership Cost on yearly basis $= \frac{2.18\,C}{10{,}000}$ per hour

Minimum ownership cost per yr. $= \frac{2.18\,C}{10{,}000} \times 2000$

$= \frac{2.18\,C}{5}$

$= 0.436\,C$

Minimum ownership cost per month $= \frac{1.2\times 1.18+1}{10{,}000} C \times 250$

$= 0.0604C$

Minimum Ownership cost per week $= \frac{1.4\times 1.18+1}{10{,}000} C\times 60$

$= 0.015912C$

Minimum Ownership cost per day $= \frac{1.6\times 1.81+1}{10{,}000} C\times 10$

$= 0.002888$

Minimum Ownership cost/hr. $= \frac{1.7\times 1.18+1}{10{,}000} C$

$= 0.0003006\ C$

9.6.7.2 *Operating Cost*

Operating expense/hr. $= 1.33\ F + \frac{Ln}{H} + \frac{T}{h}(1+r)$

$H = 10{,}000$

$n = 5$

$r = 0.15$

$h = 2000$

$$1.33\ F + \frac{5L}{10000} + \frac{T}{2000}\times 1.15$$

$$= 1.33\ F + \frac{L}{2000} + \frac{1.15T}{2000}$$

$$= 1.33\ F + \frac{L+1.15\ T}{2000} \quad .. \quad .. \quad .. \quad .. \quad Z$$

9.6.7.3 *Ownership & Operating Cost.*

On Yearly basis . . .	X+Y+Z
On Monthly basis . . .	1.2 X+Y+Z
On Weekly basis . . .	1.4 X+Y+Z
On Daily basis . . .	1.6 X+Y+Z
On Hourly basis . . .	1.7 X + Y + Z

9.6.7.3 *Ownership & Operating Cost.*

Assuming overhead charges at 12.5% of the Ownership charges and the Operating Charges.

Total rental charges would be as follows:—

On Yearly basis . . .	1.125 (X+Y+Z)
On Monthly basis . . .	1.125 (1.2 X+Y+Z)
On Weekly basis . . .	1.125 (1.4 X+Y+Z)
On Daily basis . . .	1.125 (1.6 X+ Y+Z)
On Hourly basis . . .	1.125 (1.7 X+Y+Z)

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The final equation, as it results from the above formula, clearly expresses the hourly rate of ownership and operating expense. This provides a ready reckoner for assessment of the hourly ownership and operating expense in relation to given items of machines in terms of acquisition cost thereof. It is, however, pertinent to mention that in working out the exact figures of hire charges the exercise should b ecompleted as a whole and the resultant equation as devided above, may be used for rough estimation purposes only.

9.7 *Terms and Conditions*

In what has been stated above, in this Chapter, the basis of framing hire charges for equipment has been explained in details. In order, however, to safeguard the interests of the equipment owner with respect to recovery of annual equipment costs in full, simultaneously providing for likely expenditure on repair and overhaul of equipment, it is most essential that the agreement to be signed between the equipment owning authority and the contractor who takes it on rental basis should make clear stipulations with regard to the following items:—

1. Rental Period
2. Rental Rate Basis
3. Over-time Rate Basis
4. Terms of Payment
5. Loading and Freight Charges
6. Notice of Return or Recall
7. Sub-leasing of Equipment
8. Relocation of Equipment
9. Repairs and Maintenace
10. Inspection.

9.7.1 *Owner to Prescribe terms and conditions*

Whereas the equipment owning authority would be in the best position to prescribe suitable terms and conditions in relation to all other items listed above, in relation to "Rental Rate Basis", "Repairs and Maintenance" and "Inspection" certain explanation may be necessary, if a uniformity is to be maintained by all concerned letting out equipment on hire to contractors. This is explained in what follows (based on typical provisions made in such contracts in USA; this is for guidance only).

9.7.2 *Rental Rate Basis*

Normal basis of assessment of rental rate has been defined in respect of 'Ownership Cost' and 'Operational Costs'. Situations have however, occasionally arisen when a contractor, having taken equipment on rental basis from the project authorities for long durations of time—2 to 3 years, has contended that he can ensure sustained maintenance and repair of equipment for proper efficiency in operation, only if the work of repairs to equipment is left to him. In such a case, the entire expense on repairs to equipment is offered to be borne by him. He has accordingly, further suggested that the element of cost on account of repair charges to equipment may be taken out of the hourly hire charges figure. Whereas in principle, this is a reasonable demand, but considering all other aspects, this may not be a profitable proposition for the equipment owner to accept, specially when a piece of new machine is hired out to a contractor and he uses it for a period of two years or about 4000 working hours and then returns the machine to the equipment owner. In such a case, the actual repair charges of the equipment as may possibly be incurred by the contractor, may not be commensurate with the intrinsic wear and tear suffered by the machine during that period. The magnitude of repairs that would be actually involved, when the machine is returned to the equipment owner, would be an additional burden to the equipment owner for which he has not been properly compensated, if the element of repair charges/cost is completely discounted from the rate structure of hire charges. If, however, the contractor is reasonably expected to use the machine for its entire life span, on the job he is executing, the equipment owner can consider this element of cost to be discounted from the rate structure of hire charges. In actual practice, such a condition can be seldom met with; and most often if the contractor has to use up the machine on the work awarded to him on contract, he would opt to own the equipment even though the initial expenditure on acquisition of the machine may be incurred by the project authorities. Recovery of the cost of equipment in such a case, is made from the running bills of the contractor for the given items of work. Hence, to avoid any ambiguities in this regard to arise at later date, it is considered advisable that the rate structure of hire charges on account of ownership expense should include the element of cost on repairs and the repairs be carried out by the equipment owner at his own cost periodically. To the extent any running repairs are to be carried out by the contractor, certain amount of rebate could be given to the contractor, commensurate with the actual expenditure on this account with the knowledge of the equipment owner.

It is, therefore, considered essential that in inviting bids from the contractors for given items of work where the departmental machines would be let out on hire charges, the Rental Rates relative to particular items of machines must be clearly mentioned in the notice inviting tenders for the given items of works. Unless this is done, unending disputes and controversies arise in the matter of assessment of recoveries to be made from the contractors.

9.7.3. *Repairs & maintenance*

The lessor is generally required to supply the equipment in good operating condition. The lessee acknowledges by signing the contract that he accepts the equipment as being in good operating condition. Lessee also is to agree that he will pay extra all costs of repairs during the rental period, including all labour, materials, parts and other items, except for normal wear and tear.

Normal wear and tear is defined as use of the equipment under normal working conditions with qualified personnel providing proper operation, maintenance and service. If repairs exceeding the normal wear and tear are necessary upon return of the equipment, the lessor is authorised to make such repairs and bill the lessee. The lessee agrees not to cover, alter, substitute or remove any identifying insignia displayed on the equipment. Lessee will not permit equipment to be abused, overloaded are used beyond its capacity.

9.7.4 *Inspection*

Before taking over the equipment on rental basis, the lessee may like to inspect the equipment. If such inspection is not done by him as a party to the agreement, but he deputes an agent to carry out the same, to the cost of such inspection will be borne by the lessee. In any case, it would be incumbent on the lessor to supply the equipment in good order and if, in the course of such inspection, any deficiencies on repairs get indicated in order to put the machine in good workin gorder, these could be made good or carried out by the lessor prior to handing over the machine to the lessee.

On the other hand, the lessor will have the right at any time, to inspect his own equipment and will be given free access to it as well as the necessary facilities to accomplish the inspection.

9.7.5 *Collection of Data*

As an important part of the inspection, will be the collection of data in relation to hours of operation of equipment, fuel consumption, lubricant consumption and the visible wear and tear of the parts/components of the machine, the lessor may devise certain proformae for reporting upon the operational performance and maintenance of the equipment so that recovery of rental charges is also facilitated.

A set of proformae that may be prescribed for this purpose are the following :—

1. Daily report of operation of equipment given on hire.
2. Daily report of repair carried out to equipment given on hire.
3. Daily maintenance report.

Appendix 9.3.1 to 9.3.3 indicates these specimen forms.

9.8 **Summary of Observations and Recommendations**

The number of private agencies/contractors in the country, who own the equipment for construction works, is very small. An average contractor does not cheerfully accept the idea of making huge investments in capital equipment in view of the uncertainity of the future potential of work on which he may use such equipment. Hence, most of the contractors look forward to taking equipment on hire charges from Government agencies for whom they have to work.

In letting out the machines on hire charges to contractors, the equipment owner feels concerned with recovery of investment costs—capital cost of equipment, interest charges and the repair costs at least in proportion to the time of use of equipment. The contracts for hire charges of equipment, unless are governed by pre-defined commercial or contractual terms and conditions, generally raise un-ending disputes between the lessor and the lessee.

Since repair costs are generally heavy and indeterminate, he attempts to provide safeguards at least for the cost that may accrue to him in restoring the equipment to good working order after its return by the contractor, while the contractor may attempt to make the maximum use of equipment with comparatively lesser input on maintenance and repairs. Hence, the equipment owner has to so construct the rate structure of hire charges, that no loss is incurred in the process of hiring out of equipment.

Since even the identical items let out to the contractors may not have the same initial purchase price or acquisition cost figures, it is difficult to prescribe a rate of hire charges for given items of equipment as a standard for reference by all equipment owners/contractors. At best the uniformity in the elements of costs in the hire-charges rate-stracture, and the rate of assessment of each can be prescribed.

Recommendations

1. The rental rates or hire charges of earth-moving and construction equipment should be assessed at a uniform basis by the Government Departments in the country and the following elements of costs should be considered for this purpose.

(i) Rate of depreciation;

(ii) Interest Charges;

(iii) Repair costs;

(iv) Operational labour charges;

(v) Cost of fuel, lubricants, greases etc;

(vi) Maintenance labour cost;

(vii) Cost of sundry items;

(viii) Overheads and supervision charges.

2. Straight line Method of Depreciation should be adopted for calculating the hire charges. No salvage value is to be considered in such cases.

3. To safeguard against idle depreciation due to underutilisation of machines given on hire, basic minimum charges for defined periods of loan of equipment should be fixed.

4. To safeguard against the burden of idle depreciation due to machines lying idle for certain periods without being given on rent, the following practice should be adopted to provide for the additional charges:—

(i) The life of equipment be fixed at a slightly lower figure than the normal schedules for departmental machines.

(ii) The rental rates of hourly basis, daily basis, weekly basis, monthly basis, should be assessed at a slightly higher figure.

(iii) The rate of higher charges for specified items of equipment and the conditions of contract should be clearly mentioned in the notice inviting tenders for work by the contractors where departmental equipment will be hired out to them.

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CHAPTER 10

MAINTENANCE PROCEDURES

10.1 Definition

Briefly speaking, maintenance is the function of keeping a commodity, a structure, an integrated assembly/component, or a product, in its original form, so that its functional properties do not deteriorate to a point where it may involve hazards due to its growing unsafe or result in loss in productive capability thereof, if it is used for production.

10.2 Functions of Maintenance

The functions of maintenance can be summarised colloquially in three words, "SEE, OBSERVE AND SEIZE". The importance of each letter in these three words integrate some of the important functions of maintenance engineering. The functions connoted by each letter of these words may be summarised as follows: —

Systems Planning, and its
Effective implementation
Economically, to
Obviate
Breakdowns through proper
Selection of good equipment with good
Engineering design features; and
Record Keeping, their
Valuation entailing
Expedition to timely action, and

Stimulating
Effective management; and
Inspection with
Zeal and
Efficiency.

The integration of all the factors, as above, in the above slogan, is the crux of the maintenance engineering problems, where management is directly involved to manage optimum utilisation, maximum productivity, least down time and minimum cost.

Seeing things with a keen eye, observing the results of performance through vigorous inspections and analysis of records and getting seized of the seriousness of the situation in case the observations point towards serious causes for breakdowns and downtime of the machine, would largely define the responsibility devolving upon those who are assigned the task of maintenance relative to given equipment or plant.

10.3 Types of Maintenance

Basically maintenance can be classified under the following 3 categories: —

1. Scheduled maintenance.
2. Preventive maintenance.
3. Breakdown maintenance.

Before going into the functional aspects of the above maintenance procedure, it is necessary to summarise the present procedure adopted by different users, the details of the function of various types of maintenance will be discussed in the later portion of the Chapter.

10.4 Maintenance Procedure as Adopted by the Different Users.

The word 'Maintenance', as is generally understood in relation to most of the items of construction plant and equipment, is taken to imply that a prescribed and scheduled maintenance drill, laid down in the form of a programme, a chart and specification, be followed, in respect of the particular grades of oils and greases to be used, the points of lubrication to be attended, the period of intervals at which repetitive greasing or lubrication or oil changes have to be carried out, or replacement of filters etc., is to be made. The direct benefits accruing from maintenance work generally, or the cost saving implications of such maintenance, are not comprehensively understood. After all, maintence helps reducing breakdowns in equipment, and consequently helps reducing downtime costs, besides increasing the production by the available equipment through

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its optimum utilisation. Hence, the amount of investment in maintenance of equipment, whether by way of personnel who would perform this work, or the facilities that would make the personnel do it appropriately, would pay much larger dividends in comparison to such investment.

It has also been observed by the Committee that most of the users of equipment are given to the practice of breakdown maintenance only. Attention is paid to the repairs of the machine as soon as it is laid off due to some or other trouble or a breakdown. The proverbial principle of "A stitch in time, saves nine", is seldom followed by large cross section of the users of equipment.

10.4.1 *Responsibility in Maintenance*

There is no doubt that the programme of maintenance based on the charts and the specifications for periodical attention, becomes a routine affair with those who are assigned with this work; but unfortunately, more often, it gets to be a routine of a type, where the person in charge of the maintenance work, reduces his responsibility to the task of putting only tick marks in token of attention having been paid to specified items of maintenance work defined in the charts or specifications. Many a time this is done even by sitting in a cabin based on the assurance given by lower staff that the work has been done. With such a routine very little initiative is exercised by the maintenance personnel in the direction of preventive measures to be taken to avoid mechanical breakdowns in the equipment. They are forgetful of the importance of the proverb "Prevention is better than cure". If the cost saving implications of maintenance are to be clearly understood, the maintenance personnel are to clearly comprehend that it is 'Preventive Maintenance', which is to be carried out in a more rigorous manner than the prescribed or schedule maintenance based on predefine dcharts or specifications.

10.4.2 *Work assigned to Junior Personnel*

The general observation of the Committee wit hregard to maintenance work done by the users of equipment is that, while the prescribed maintenance schedules relative to individual makes and models of machines are prepared properly, the work is actually assigned to a team of junior personnel most often mechanics only. The general level of intelligence/skill of mechanics being what it is, they follow the routine of maintenance work to the extent of dispensing fuel and lubricants, greasing some of the points or checking up the tyre pressure etc. They are not mindful of the importance of other aspects of maintenance work, namely, adjustments in various systems, functioning of the various systems, the condition of mechanical systems on the machine.

The mechanics who are responsible for maintenance work, do not always observe whether grease is passing through the grease nipples. They are satisfied with the task being done to the extent that they pump the grease-gun a given number of times, at a given greasing point and then forget about the rest of the involvement in particular reference to the effectiveness of such maintenance. It is generally indicated that the routine maintenance work does not include these items for proper attention. While there may be no doubt, that more meticulous care has to be taken for giving attention to most of these items, besides the routine lubrication, at periodical intervals only, it is to be stressed that with a view to obviating the chances of early breakdowns on equipment, the general condition of the machine has to be observed with a keen eye through inspection by one of the senior persons in charge of the maintenance team even when the machine comes for routine maintenance. Such keen observations by a senior maintenance supervisor/inspector will go a long way to reduce the incidence of breakdowns.

10.4.3 *Unhygienic Conditions*

One of the most important factors to be taken into account for even the routine maintenance is that of 'Cleanliness'. The conditions around the area where the maintenance work is performed and the condition of the servicing equipment, including containers used for dispensing oils and lubricants, make a lot of difference in the effectiveness of maintenance of machines. Most often we run the hazard of introducing foreign materials, grit and dirt into various lubrication system if the cleanliness conditions do not prevail. The Committee have observed with sadness, the presence of such unhygienic conditions in many places during their visits to a number of work sites where the equipment was under maintenance.

10.4.4 *Improper Accommodation for Maintenance Work*

Another point of observation relates to covered accommodation for maintenance work. Whereas roof accommodation is provided by way of sheds etc., for maintenance of machines, the floors under these sheds are not pucca and most of the times mud and dirt removed from the machine gets piled up on the floor and removed only at long intervals of time. Even the storage of POL items is under very untidy conditions. The prescribed practice of using volume pumps, semirotary pumps and oil pumps on top of the drums containing lubricants, is not followed.

10.4.5 *Operator's Inspection*

The Operator of the machine who has the proper sense of feel, regarding performance of equipment, is seldom made a partner in the maintenance work. In fact, the Operator is in most advantageous position to place into practice the six points of preventive maintenance:

1. Execution of the maintenance programme.
2. Visual and instrument check.
3. Feeling (heat supported by measurement).
4. Lubrication.
5. Cleanliness.
6. Adjusting.

The Operator is the man who sense the possibilities of future trouble on a machine. His inspection reveals small problems. These can be corrected before costly repairs become mandatory. The operator's inspection is at the heart of any good maintenance plans. Based on his report, systematic inspection prevents premature breakdown and accident. It is, therefore, of paramount importance that the operators must be made partners in the maintenance programme.

10.4.6 *Inadequate Training Programme for Maintenance Staff*

The Committee did not come across any training programme for maintenance staff at most of the places. It is necessary to impart basic education to the maintenance crew regarding types and grades of lubricants to be used on particular machines working on the project, as also the proper maintenance drill to be followed besides the routine and prescribed maintenance illustrations in charts and specifications. The only way of imparting this education, as adopted by some of the users of equipment is the preparation of specifications of lubricants, the intervals of change of filters, the intervals of change of engine oil, hydraulic oil, final drive oil, transmission oil etc., and display these on painted black boards. While it may be admitted, that an average maintenance mechanic would be supposed to refer to these blackboard specifications while dispensing lubricants or greases to particular makes and models of machines, most often. the available lubricants being different from what is indicated on the black-boards, there is possibility of a mix-up in the grades of oils to be used on different items of a machine. Cases are not rare when use of wrong oils on different systems of machines caused serious troubles and also serious damage to equipment. It is only through 'in-service' training programmes that a better climate can be created for proper maintenance programmes.

10.4.7 *Use of Unskilled Personnel in Maintenance Work*

It has also been observed by the Committee that far too many people are employed on maintenance work. Besides a host of mechanics, a large number of helpers are also put on the job. This results in wasteful expenditure on the maintenance cost of machines, besides causing inapt attention to the particular work to be done by the maintenance team.

10.4.8 *Cleanliness of Machines*

Another important aspect of maintenance work for such equipment is the occasional steam bath to be given to them, or the pressurised water jet cleaning thereof. It was only in rare cases that the Committee came across such equipment being available for steam cleaning of machines. Pressurised water-jet arrangement for cleaning was of course, available at a number of places; but the frequency at which the machines were subjected to the cleaning exercise was rather small. In fact, the Committee observed that on some of the jobs where dusty conditions prevail due to the type of material being handled or the type of duty being performed by the machines, and with the machines being located at somewhat higher altitudes in humid conditions, the overheating of machines, or premature breakdowns due to heating etc., made the owners of equipment discard the equipment at rather short intervals in the life of the machines. The dust had almost got caked on the exposed surfaces of the machines getting mixed up with lubricants and naturally, therefore, the machines could not have been expected to perform any better. Opposed to this. at one of the locations, the machines working under identical conditions, were pleasantly tidy and clean. They had the steam jennies in use with them; and they had made a religious practice to giving the machines a steam bath once a week. Most often it was at 100-hr. maintenance time that such treatment was given to the machine. The life of the machines at that work-site was over 2 times the life obtained at other locations. The dividends paid by this little attention to a minor maintenance exercise, are very evident to be over-emphasised.

10.4.9 *Working Conditions*

As already stated above, the general understanding of the word 'Maintenance' limited to the field of attention to the machines only. Lack of comprehension of the important aspects of this work, as illustrated above apart, the basic understanding regarding condition in which the machines have to work (and these generally contribute to early breakdowns, upsetting of adjustments or make the operation of the equipment hazardous and unsafe), is another important factor. This would specifically start from the maintenance of the haul roads to be negotiated by most of the equipment or the maintenance of the borrow pits, and the fill area in so far as the working of excavators, tractors and dumpers is concerned. Here is where the basic science of earthmoving gets involved. Increased rolling resistance due to bad surface of haul roads, soft surfaces causing penetration of tyres and corresponding increase in rolling resistance, sharp bends and curves, or steep gradients which cause loss in speed and power, the rutted surface which put a curb with the speed of the units besides causing greater amount of wear to the rubber on the tyre surface, the extra wet conditions some times, which cause slippage of tyres and the resultant wear and tear and loss of tractive effort in the machine are some of the points which cumulatively cause heavy loss through reduced production and quicker wear on various parts and components of the machine. It is unfortunate that very little attention is paid to this aspect of the work—haul road maintenance, by a large number of users of equipment. Here again, of course, there are exceptions where model set up have been observed by the Committee during their visits to project works; but by and large, this is one area, where lot of improvement in maintenance work is necessary. To quote one solitary case, which has come to the notice of the Committee, the total number of hours worked by the graders on a project, accounted to one hour per day, when equipment worth Rs. 8 to Rs. 10 crores was in use on the project, with the total number of machines over 100. The gradients to be negotiated by the machines on that location were also very steep and due to roads not being maintained properly dust clouds were raised whenever the machine passed certain areas. No wonder, the overall utilisation of equipment under such conditions, was low.

10.4.10 *Model Set-up*

Opposed to this, the Committee did come across model set ups where pressurised greasing, with proper servicing equipment installed under covered accommodation with pucca floors could be seen. Besides this, the persons in charge of the maintenance did meticulously observe the effectiveness of maintenance. He did maintain a proper record of all points of attention, including adjustments, cleanliness, observations regarding condition of the components and assemblies, leakages of oil, looseness of bolts etc. It was only on these few users' work-sites and maintenance sheds where such reporting system by the operators could be seen, though to a partial extent,

10.5 Scheduled Maintenance

This can generally be taken as the maintenance programme prescribed by the manufacturers laying down a schedule for greasing, lubricating, changing oil, cleaning of machines etc.

Such maintenance work is generally carried out by a team of service gang in the field unit during the operating shifts, in between the operating shift or after the operating shifts as the case may be.

10.5.1 *Distribution of Maintenance Work at Work-site.*

At the worksites if each set of service equipment has a team of only five men, including one foreman or chargeman in charge of the maintenance work, the work of maintenance can be done very effectively. While chargeman or foreman would make general observations and notes regarding condition of the machine in specific context of adjustments based on operators' report, cleanliness, looseness of bolts etc., one person from the team could attend to the engine or power unit, the second one for greasing of the points on the non-engine side, the 3rd one to check up the tyres or undercarriage on the machine, while the fourth may check up the water in the cooling system and the level of oils in various other systems etc. As far as possible, except for the crew who have to handle material, the use of helpers may be avoided. This would help in establishing a better standard of maintenance due to better level of intelligence and skill on part of the mechanics employed for maintenance work. The expenditure on such trained mechanics for maintenance work will be comparatively lesser as a total, when compared to the wages of the entire staff on maintenance work, including a host of helpers.

10.5.2 *Use of Mobile Servicing Units*

On jobs where the number of machines employed is fairly large, or the equipment spread is wide and the maintenance of machines is to be done every shift, it is necessary to have mobile service units for such maintenance work. These mobile service units either on wheels, or skid mounted, are placed at suitable locations on the haul roads. Each machine is in turn stopped at such service points while it is returning from the fill area, after dumping load. Here again, a team of five persons, including a senior person—chargeman or foreman, is in charge of the maintenance work. It normally takes 10 to 15 minutes only for the maintenance work to be done on one machine with a mobile service unit. In fact, if this work is properly organised, it may not take more than 5 to 7 minutes to service a machine, by way of shift maintenance work. The time taken, however, is commensurate with the skill on part of the persons engaged on the maintenance work. Here again, the story to be told by the operator regarding performance of the machine, is to be properly heard by the chargeman, or foreman and taken note of with judicious observation and assessment.

10.5.3 *Maintenance of Crawler Equipment*

Maintenance of motorised equipment, where large fleets of such equipment are in use, is generally done by mobile/skid mounted service units positioned at suitable placed on the haul roads. However, in respect of crawler mounted equipment—crawler tractors and excavators etc., the servicing is to be done by taking the service units to the machines wherever they are located. In case truck-mounted service units are in use and the work pattern, shift-wise, is such as would permit movement of these mobile units to the crawler-mounted equipment, these could be used for servicing of those crawler mounted machines as well. Where however, round-the-clock work is going on and the number of pieces of motorised equipment is so large that the service units positioned along the haul roads cannot be moved, separate provision foi mobile service units for servicing the crawler-mounted equipment would be desirable.

10.5.4 *Maintenance During 3-shifts Operations*

It may also be a wise policy to consider clearly as to what would be the periods during which the equipment maintenance be carried out. If the production work is to continue round the clock for 24 hours, it would be necessary to attend to the daily maintenance work while the machines are engaged on actual production work; and the practice, as described in para 10.5.2. for providing mobile service units, could be adopted with advantage. In addition, sometimes the interval between two shifts (when a time gap between the 2 successive shifts is available in 3 shifts operations) enables the machines to be attended to for maintenance. The excavators and crawler tractors would mainly fall in this category. In addition, it is a practice with some of the equipment users that some of the pneumatic tired units also are attended to for maintenance during this time of interval between 2 shifts. In case the fleet of equipment has large number of machines in it, a judicious combination of the two systems is adopted.

10.5.5. *Timing of Maintenance Work.*

In case of 2-shifts work during the day the work of maintenance on the machines is done in the normal manner with mobile servicing units, or in the field maintenance shop. In case the time interval between the two working shifts is of the order of 2 to 4 hours, there is time enough for the maintenance of the machines during that period in field maintenance shops. If the time interval between the two-shifts is not large, after the 2nd shift and during the period between the night shift and morning shift, the work of maintenance on the machines may be done in a separate maintenance shift. The timing of such separate shift for maintenance can be changed according to convenience of work and the management. For example, if two continuous production shifts get finished during the time from 6 a.m. to 10 p.m., the maintenance shift would be during the time 10 p.m. to 6 a.m. on the following day. At predetermined intervals of time, say weekly, fortnightly or monthly, the production shifts may be shifted by 8 hours in a calendar day, in which case, the maintenance shift which was timed for 10 p.m. to 6 a.m. would be shifted to 6 a.m. to 2 p.m., and the production shifts would be shifted to the period of time 2 p.m. to 6. a.m. Such rotation of production shifts and maintenance shifts could be properly planned.

In certain locations where the spread of work is very wide——specially on canals, and the operating and maintenance staff are situated near around the sites of work, it is also customary to have the maintenance staff on the job after 2 to 3 hours after the commencement of the production shift, so that they may cover the maintenance of the machines even during the interval time between the two shifts or attend to some special adjustments etc., even after the production shifts are over.

In case the work is done in three production shifts round-the-clock, the maintenance shift timing is coincident with the production shift timing.

10.6 **Preventive Maintenance**

"Prevention is better than cure". The 'Preventive Maintenance' controls repair costs by preventing small problems from turning into major investments by putting the 'free' into 'trouble free'; contributes to long and profitable equipment life; influences equipment operation close to maximum rated capacities; guards against unscheduled down-time; and works against accidents involving people, property and machinery.

10.6.1 *Significance*

Let us understand the significance of this idiomatic phrase "Prevention is better than cure". What do we prevent in relation to equipment and in context of 'Maintenance'. We attempt to minimise the downtime of equipment by seizing the opportunity to pay proper attention to certain areas on the equipment, so that before the breakdowns occur, preventive action is taken. Prevention of breakdowns in turn ensures better availability of equipment for production work. Thus, through such prevention of breakdowns, we ensure better production with machines. Through such better production we attempt to achieve economy in end cost of the product produced by these machines. Hence, ultimately the "Preventive measures" get related to equipment economies.

10.6.1.1 *Equipment Economics*

The subject of equipment economies gets into cnosideration right at the outset while planning for any mechanised operations on a given job. We look forward to having such equipment for given items of work as would involve least maintenance or where the soundness of design of different components and systems of the machine would ensure better reliability and lesser incidence of breakdowns or downtime. Even for similar machines of different makes and models, relative consideration would arise with regard to comparative technical characteristics of specifications and construction features. The consideration for selective choice of equipment is therefore also important in relation to "Preventive maintenance".

10.6.1.2 *Functional Aspects*

The functional aspects of preventive maintenance would include. (1) selection of equipment; (2) record keeping; and (3) care of equipment. The importance of each one of these items is described below.

10.6.2 *Selection of Equipment*

10.6.2.1 *In-built features*

Selection of machines play an important role in proper maintenance. The inbuilt features in a machine need proper study for selection, so that the maintenance work is easier and cheaper. For example, a machine with life-time lubricated bearings can be given preference to a machine where the bearing needs attention every 8 hours or 16 hours of operation.

In relation to major items of earthmoving machines, these aspects of economy are properly integrated in the machines of different makes and models as put on the market by various manufacturers. In making the selection of equipment initially, to meet the requirements of a particular item of work, one has to bear in mind clearly as to what maintenance features are built into the machine, how far does the rated production capacity and other specifications aptly suit the job requirements and above all, are the design features compatible to the overall concept of economy in running, maintenance and repair etc. The extent to which the maintenance and repair effort will be comparatively lesser considering "ready to use" machines of different makes and models, would help evaluate as to which particular make and model of the machine should be selected for a given item of work.

10.6.2.2 *Design features*

While selecting a machine preference would be given to the machine having good design features to withstand the severity of work on which it is to be employed and the quality of the components and parts of the machine, so that the machine does not suffer frequent breakdowns requiring maintenance attention all the time. A decision to accept a design is to assume the advantages and disadvantages associated with it. After all in relation to earthmoving machines and construction plant and equipment, the design of machines and equipment are integrated units of economy of production, economy of interchangeable designs, economy of material selection, economy of perfection, economy of size, economy of standardisation and simplification and economy of method etc. It is this process which is termed as "Selective choice of equipment."

10.6.2.3 *Total Cost*

Briefly speaking, one is guided by the total cost involved in life time of a machine in the matter of operation, maintenance and repairs etc., for optimum production. A machine having less maintenance expenditure over a given period even though slightly costly at the beginning, can be preferred to a machine which is expensive in the maintenance during the period even though comparatively cheaper in the initial cost.

Furthermore, by selecting a piece of equipment, the user of equipment must evaluate the reliability of the components and parts and carry this over into the relative price of a competitive equipment.

10.6.2.4 *Standardisation*

This is one aspect of selection of equipment for easier and effective maintenance work. Non-standardisation causes problems in maintaining stock of spare parts, providing adequate facilities for maintenance and repairs and getting properly trained personnel for operation and maintenance.

10.6.3 *Critical Analysis of Equipment for Better Maintenance*

10.6.3.1 *Break-up of equipment into components and functional systems*

The design and construction features of a machine would enable one to understand the integration of components, sub-assemblies and assemblies, which go to make piece of equipment. It is this basic understanding of the construction and design features of the equipment which make the most vital and key point for preventive maintenance. After all, any piece of equipment has to be broken down into basic items of which it is comprised, so that the areas of maintenance are clearly understood in relationship to the functions of each such component. This facilitates the convenience of determining the particular causes leading to breakdowns, intensity of periodical inspections that would be called for to enable clear assessment of the condition of the components, the extent of wear and tear suffered by them, the extent of life these components will last in operation, and consequently, the time when these would have to be repaired or replaced. Abnormal wear of certain components may necessitate clear insight into the cause of excessive wear. As an example, if, during the course of inspection, it is observed that a particular gear in a gear-train, has worn out excessively, the main cause for this may have arisen out of the fact that the shaft and bushing of another meshing gear had worn out prematurely, resulting in excessive wear in the gear teeth on the gear under inspection. If such break-up of the components of an integrated machine is not clearly understood, the resulting expenditure for repair and maintenance may be excessive upto the point of replacement of the whole assemblies in a machine, or the machine itself.

To illustrate the principle in practice, let us refer to the crawler tractor—a machine most commonly used in construction industry, mining industry, road building, reclamation work, port development etc., etc. The machine could be broken up into the following components, group-wise:

1. Diesel engine, or power unit.
2. Clutch and transmission.
3. Final drive with power-take-off.
4. Under-carriage and Track Group.

The systems on the machine corresponding to these component groups would be as follows:—

1. The cooling system.
2. The electrical system.
3. The fuel system.
4. The engine as a whole (besides the above systems)
5. The lubrication system.
6. The clutch.
7. The transmission.
8. The hydraulic system for transmission, operation, steering etc.
9. The final drive.
10. The power-take-off.
11. The track-link-assembly.
12. Carrier and track rollers.
13. Sprocket and idler wheels.
14. Springs, suspension, draw-bar, equiliser-bar etc.

In case apt attention is paid to the necessary inspection and service of the systems as above, one can be certain of trouble free performance of the Tractor as a whole over a fairly long period of time.

10.6.3.2 *Inspection—aid to analysis*

The analysis of individual systems for inspection and maintenance has to be in symptomatic terms. It is, the break-up of the machine into mechanical systems, understanding the systems properly together with the components that are involved therein, that the trouble-shooting work or fault-finding work could be clearly done and an assessment made.

Given below is a typical example to illustrate the basic concept of how such analysis of troubles on the machine could be made with precision and expedition. In practice, this will be true of any machine whether inside a workshop or a plant as a whole, or a piece of earthmoving or construction equipment. We have only to split up the machine or a plant or equipment into different important integral components and systems and lay out clearly an outline of the points of attention, so that proper assessment of the faults or amount of wear and tear occuring in those components could be checked in time.

For instance, if there is excessive wear on the track rollers, on the idler wheel, or on the sprocket, or even in the track-links, one has to clearly understand after observation and analysis, as to whether the track is mis-aligned, is the track tension right, is there some mud deposit making the track-chain rather taut; are there any loose nuts and bolts on the roller-brackets; is there abnormal wear on the shaft and bushing of the rollers or idler-wheel; has the pitch of the track-links increased too much; is the wear on the bushes and pins excessive; or, has the depth of wear on the track-links become rather excessive. It is by a process of check and elimination that one could soon get to the basic source of trouble in the track system as a whole on the crawler tractor, to know precisely as to where does the fault lie and what could be the consequences if that fault is not remedied in time.

On the other hand, let us think of the performance of the diesel engine on the crawler tractor. If the engine is getting overheated, one has to check up whether the cooling system is functioning alright or not; what is precisely wrong with the cooling system—it could be, clogged radiator grill, muddy water with silt deposit inside the header tubes, or tank; ineffective lubrication system even overloading of the machine in the duty being performed etc., etc. In addition to the cooling system, the inside condition of the engine as a whole, could at times contribute towards over-heating of the engine. If the trouble-shooting process is properly resorted to in determining the exact cause of the possible faults that may be contributing towards over-heating the engine, one could soon get to the precise cause of the trouble and attend to the same before the diesel engine on the crawler tractor gets to a point where a major repair and overhaul is necessary.

10.6.3.3 *Major repairs——inference from inspection analysis*

As a result of periodical inspections a clear record is created of the pattern of wear and tear of machanical parts etc. Judging these measurements relative to standard measurements of new parts and permissible limits of tolerances and wear clear decisions can be taken about the need for major repairs of any component sub-assembly or the machine as a whole. The need for major repairs is thus usually determined as a result of periodical inspections.

10.6.4 *Record Keeping*

10.6.4.1 *Personnel for record keeping*

An effective engineering and maintenance department must be responsible for record keeping, both for productive capabilities of equipment and for maintenance data. Often, a mistake is made by delegating this function to a purely clerical department, which is not well enough acquainted with the purpose of the records, and as a result, may present computations which are either irrelevant, or misleading. Besides, the conventional clerical system is prone to relate all data to the end-product of the operation (in terms of profit per unit cost of the product) though in engineering and maintenance studies, this would not furnish the detailed analysis as required.

10.6.4.2 *Records to be maintained*

The records should largely indicate monthly costs of maintenance—expenditure on repairs—availability and productive capacity. Reasonably accurate records kept continuously, give a very accurate picture of the performance of equipment, and are considered more valuable than the results obtained by spot studies. These records may also give important information for repair and replacement studies while would enable the users of equipment to make an appropriate choice of the equipment for the given job with due regard to productivity and production costs. Records on history of performance of the equipment has to be properly kept. This would include starting from the consumption of P.O.L. to the expenditure on repair and maintenance and the down-time. Through such records the work on preventive maintenance can be effectively controlled.

The records of wear readings and behaviour of different components and sub-assemblies of the machine has also to be watched at regular intervals. This would help in timely action being taken for repair/rebuilding of the components for extending its life and avoiding premature failures and discard.

10.6.5 *Care of Equipment*

10.6.5.1 *Physical limitation*

The main point in care of equipment is to limit the function of a piece of equipment to the physical limitation imposed by the specification of the equipment for doing certain functions. No doubt, adaptations can be made, or modifications introduced, to make a piece of equipment versatile for performing functions beyond those for which the machine has been designed. However, the basic specifications governing the design of the components cannot be ignored. One of the pertinent things to consider is to put a limitation on effort to squeeze more production from a piece of equipment than it has been designed to do. Many a time, a 10% increase in productivity is gained at the expense of a 50% increase in maintenance cost. Here again, records can be used to evaluate these factors; in such cases, the maintenance organisation should be consulted and their judgement respected.

10.6.5.2 *Lubrication*

Another point for proper care of equipment arises in good and constant lubrication, which is absolutely necessary for effective preventive maintenance. For maximum benefits, the points for care in this respect, must be assigned to a responsible authority, to carry out such a programme, which is largely the scheduled maintenance programme.

Provision of proper facilities for lubrication and greasing etc., is the most necessary adjunct to the equipment if the care is to be exercised to the required degree. A competent Lubrication Engineer can add a great deal to the potential profits of any industrial undertaking.

It is also necessary that a minimum number of brands and grades of greases and oils should be put to use for the lubrication of various machines at a given site of work. This will not only help minimising the chances of mistaken applications and wrongful use, but would also facilitate minimising and simplification for stocking and replenishment of these items.

10.6.5.3 *Inspection*

As mentioned in para 10.6.4., regular inspection of equipment is another area where care taking makes the results of benefits more manifest. More money can be saved by finding faults before major breakdowns occur, and therefore, this job grows in importance as the equipment gets larger and complex. A conscientious inspection programme would go alongwith the scheduled maintenance work.

10.6.6 *Economics of Preventive Maintenance*

The amount invested in preventive maintenance by way of separate personnel to perform this work would pay back many times through larger dividends. Most often, it would be convenient and possible to re-allocate certain functions to a group of selected persons from the existing maintenance personnel, and therefore, no extra cost may even be involved.

Referring to a piece of an earthmoving machinery most popularly used—a crawler tractor, the value of track group components on this machine amount to about 20 to 25% of the cost of the machine. The ageing quality of most of the items in the track group is directly related to the quality of the components—its capability of being wear-resistant due to the degree of hardness introduced in the wearing surfaces. If the wear and tear on the components is kept under watch, through periodical inspections, at regular intervals, and if the wearing surfaces are not allowed to wear beyond permissible limits at which rebuilding process is introduced, the whole set of components, or integral parts can be reclaimed for conservation through the process of rebuilding by welding. This saves about 50% of the cost of these components, or 10% of the cost of the machine.

The dissertation as above, can be generalised in extending the principle for application to any components, or parts in various items of equipment in use for production work in different fields. For this purpose the machine can be broken up to various Systems as indicated in para 10.6.3.2. above.

In brief the records to be maintained in the history book and the records on preventive maintenance are to be carefully maintained by a qualified engineer so as to make the preventive maintenance work easier.

The following example illustrates the economy resulting from preventive maintenance on the track components of a crawler tractor and indicates the savings that may accrue.

Assumptions:

Preventive maintenance group to look after 20 tractors.

Assistant Engineer	1 No. @ Rs. 600 p.m., 7200/Yr.
Supervisors .	2 Nos. @ Rs. 400 p.m., 9600/Yr.
Foreman . .	2 Nos. @ Rs. 400 p.m., 9600/Yr.
Clerk . .	1 No. @ Rs. 200 p.m., 2400/Yr.
Tractor Cost .	Rs. 5,00,000—C

Tractor Life—8 yrs. or 15000 to 16000 hrs.

Track Components cost—20% of tractor cost..Y.
Track life without P.M. 2000 hrs.
With P.M. & rebuilding—3000 hrs.
Cost of rebuilding—25% track cost—0.25...Y
Productive Capacity of tractor 3C.
Increase in production due to timely P.M. 5%

Savings:

Gross savings in track cost during life:

3 track components = 3 Y
Net saving deducting
rebuilding expenditure = 3Y — 5 × 0.25Y.
= 1.75Y = 0.35C.
Production gain = 3C × 0.05 = 0.15C
Total saving = 0.50 C.

Expenditure:

Pay of staff per year	Rs. 28800
Pay of staff for 8 years	Rs. 230400
Expenditure/Tractor	Rs. 11520
Overheads . .	Rs. 8480
Total . . .	Rs. 20,000 = 0.04C

Ultimate saving 0.46C which comes to more than one tractor for every 2.2 tractors.

Foot-note: The above example is purely illustrative of the point that proper preventive maintenance and rebuilding operation extend the life of the components to a certain extent. The assumptions made are not relevant to particular job conditions. In specific cases, the basic assumptions would have to be related to the particular job conditions and applications obtaining there.

10.7. Breakdown maintenance

10.7.1 *Unit Replacement*

While from stand point of conservation of parts as illustrated in the preceding paragraph, the subject of unit replacement gets partially covered by the preventive maintenance programme (care taking part of it), there is yet another aspect of the maintenance work which has to be considered differently from the preventive maintenance. In fact, the word 'Preventive maintenance' should be understood as "Corrective-maintenance" distinctly different from the function "Breakdown maintenance". The 'Breakdown maintenance' results in repairs arising out of deterioration suffered by a machine, or its components, in the course of its use, accidents, improper adjustments etc. Such maintenance arises even in case of minor breakdowns where minor repairs in the machanical systems may be called for. Opposed to this is the repairs arising out of major breakdowns, where, in the case of initial design of machine incorporating features by way of replaceable assemblies, may facilitate immediate replacement of the component for commissioning the machine for ready use again. It is this aspect which, under the concept of "Unit Replacement System", reduces the down-time of machines to the minimum possible. The main economy, however, in this system hinges around the fact that the worn out or brokendown components should be repaired separately and in least time, so that these can serve as standby-unit, for unit replacement on any other machine where a similar component suffers a breakdown, subsequently.

10.7.2 *Planning*

The breakdown maintenance at times, calls for a bigger task force for maintenance, than is available. Any such situations can be tackled by apportioning additional staff or manpower temporarily to meet this situation. However, one of the main requisites for meeting the breakdown maintenance work is to provide tools, handling equipment, welding sets etc., so that least time is lost in carrying out the necessary repairs. Planning ahead of time for man-power and tools and equipment for meeting the requirements of breakdown maintenance, commensurate with the size of fleet of equipment, pays great dividends, as this would reduce the loss in production time and make it possible for the required targets of production to be fulfilled.

10.8. Functional Requirements of Maintenance.

In addition to what has been indicated above, it has to be mentioned that the functional requirements of maintenance work beyond initial proper selection of equipment and inspection and servicing thereof, would cover operational procedures, efficient repairs, conservation and reclamation, proper environmental conditions, proper storage and ware-housing facilities, and above all, proper management.

10.8.1 *Warehousing Facilities*

The conservation and reclamation process has been referred to in what is stated at para

10.7.1. The storage and warehousing facilities make an equal item of functional requirements in relation to preventive maintenance work in respect of equipment, or its components. Consider a machine tool being left in the open and exposed to the vagaries of weather—sun-shine, cold heat, dust etc., and on the other hand, a piece of equipment stored properly in a proper shelter in moderate temperature conditions. The machine stored in the open would certainly get physically deteriorated much in advance of its normally expected age in operation, when compared to the age of the machine put under proper storage initially. This can be illustrated by the simple example that a piece of ball/roller bearing when left entirely dry even under a proper roof and stacked properly in the storage bins may probably rust very soon, if it has no suitable initial coating with suitable rust-preventive lubricant. Many such items, very expensive otherwise, have been lost due to inadequate attention paid to their storage. This is the significance of proper maintenance of a small item in storage. A machine is built-up of a large number of such components/parts and, therefore, if the machines are not properly stored, these may suffer physical deterioration.

Many more examples can be quoted relating to storage of tyres, batteries, wire ropes, crank shafts, gaskets, lubricants, etc., etc., to substantiate what has preceded. In fact, for each item, there would be a clear and long list of items for attention to ensure prevention of damage to the parts, or to ensure long life in service.

10.8.2 *Planned Training*

Before this subject is concluded, it may be necessary to mention that to ensure proper maintenance, right from the time any piece of equipment is commissioned on the job, the operational staff and the supervisory staff should be fully acquainted with the machines they have to operate and maintain. This alone will help to produce efficiently, safely and profitably, the required product. In fact, this would help to search for more efficient, safer and more profitable methods to manufacture the given produce. To provide for continual improvement, there is an obvious need for a high standard of competence among the ranks—both of supervision and those being supervised. To achieve this standard, planned training at every level of the organisation is a definite necessity. The trained operators and skilled trainers would both combine to make the work of maintenance much easier.

10.8.3 *Performance Evaluation*

It is for the management to establish a system of performance evaluation for the equipment in use. Such a system would render necessary information to analyse equipment failures and the owning authority or management would pass on specific recommendations to the manufacturers of equipment on remedial measures to be taken to prevent such failures in the machines. The typical failures, if analysed properly, would always help to locate precisely the major cause contributing towards the failure.

10.8.4 *Management*

To manage the functional requirements effectively, the maintenance programme could be summarised as follows: —

1. Assign responsibility for maintenance to specific personnel.
2. Understand the system selected.
3. Adhere to maintenance schedules.
4. Keep adequate maintenance records (equipment involved, work done, personnel doing the work and the dates when the maintenance is done).
5. Use of lubricants and supplies recommended for safe and efficient operation of the machines.

An effective maintenance system need not be complicated to be workable, despite the large variety of machinery that may be in use in a given location.

10.9. **Facilities for Maintenance and Repairs**

One of the most important aspects of maintenance work is the provision of facilities for expedition, ease and efficiency.

The requirements can be divided into the following 4 categories: —

1. Workshop floor space (covered and uncovered) for the repair and maintenance work,

2. Qualified and trained personnel for maintenance and repairs.
3. Proper equipment and tools, and
4. Spare parts.

These are briefly dealt with below.

10.9.1 *Workshop Floor Space*

This is to be spelt out in relation to:—

(i) Field repair and maintenance shop.

(ii) Main workshop.

Whereas the principal details in this respect will be given in Chapter 11, a brief explanation of few salient points will be given hereunder.

Field Repair Shop

The scale of provision for floor space may be generally estimated at 50 to 60 sq. ft. per machine (where the size of the machine is small), and 100 to 120 sq. ft. per machine (in respect of heavy earthmoving machinery items).

Additional uncovered floor space—an equally uncovered floor area—with concrete floor, is also additionally required to be provided in the field repair shop.

The maintenance shop should have a small store for keeping the day-to-day fast-moving spare parts and other hardware items, including filters required for the maintenance of the machines. The field lubrication and servicing units may also be located in this shop, where the mobile equipment working in the field can be brought and serviced. The field repair shop should be furnished with working benches, racks, hand-tools, lifting tackles, mobile crane, portable welding equipment etc, for executing the repairs and maintenance work with speed and efficiency.

Main Repair Shop

The subject of planning of a main repair shop has been dealt with in details in Chapter 11 with respect to type of building construction, the type and number of individual shops that the main workshop would be sub-divided into the equipment that will be provided in each shop and the functions each shop would perform in relation to general maintenance repair and overhaul of equipment. These points may not be discussed in further details in this Chapter.

However, it may be mentioned that in this case, the scale of provision for covered floor area would be estimated at 150 to 180 sq. ft. per machine for a total number of machines to be serviced in the shop. The uncovered hard surface floor space in this case may be 2½ to 3 times the area of the covered floor space set aside for the machines.

The cost of the covered and uncovered floor space and the sheds to be provided may be estimated at 1.5% to 2% of the total cost of equipment to be serviced in the shops.

10.9.2 *Requirement of Personnel*

The requirement of personnel or the strength of the maintenance and repair staff would depend on the size of the equipment fleet. It will be further related to the pattern of work shifts. The type of work on which the persons would be employed would fall under three main categories:—

(1) planned maintenance and repair work;

(2) emergency maintenance and repair work; and

(3) work on preventive maintenance.

The scale of provision of staff in each category will be as follows.

10.9.2.1. *Planned maintenance and repair work*

Whereas the prescribed and scheduled maintenance of machines is always in accordance with a set plan—either prescribed by manufacturers/suppliers of equipment or according to scheduling done by the equipment owner/user, it is always necessary to develop a clear plan for the programme of periodical repairs to the machines. The time span for such repairs is determined by the experience of the user when a machine has been in operation on a particular job for some time. Where large fleets of equipment are in use and planned programme of such repair work would clearly define the particular machines which would be brought into the shops at particular periods of time for repairs. Such repair programme would be a continuous affair throughout the year.

In relation to jobs involving concentration of equipment in limited areas, planning of repair work can be done for atleast 60 to 75% of the annual work load and all necessary provisions made to carry out the task successfully. The programme would additionally include the balance of the workload arising out of unscheduled repair jobs being assigned to the shops.

The Committee have examined the programmes of maintenance and repairs as being executed by some of the major users with a view to determining the scale of provision of skilled manpower for maintenance and repair work. Based on the data received, it is considered that this provision may be at the rate of '3' men for every '4' machines for single shift work; '2' men for every '3' machines for two shifts' work; and '5' men for every '2' machines in 3 shifts' work for maintenance and repair of machines.

The skilled men would include persons in the categories of,

(1) Mechanics—Senior or Junior;

(2) Fitters,

(3) Electricians; and

(4) Oilers and Greasers.

These figures are indicated for guidance for purposes only. The actual requirement would, however, depend largely on the type of organisation created for maintenance and repairs of machines and the provisions made by way of standby components and equipment etc.

Requirement of personnel for supervision, which would include Foreman, Assistant Foreman, Chargeman etc., would be of the order of about 10% of the strength of repair and maintenance personnel.

The above estimates do not include the requirement of unskilled personnel—in the category of helpers/unskilled labour. As already indicated in Chapter 3, the practice of employment of helpers—one each with every operator/mechanic should not be encouraged. If the helpers have to render any help, that has to be in the direction of handling heavy parts/components. Such personnel should normally be included in the gang of "Riggers"—a colloquial term used for providing persons for handling work etc. The strength of helpers and riggers could also be suitably controlled if recourse is taken to scientific methods of handling heavy components/equipment for repair work. This will involve a provision of adequate handling facilities and tools—hand-operated cranes, lifting tools and tackle, pillar cranes etc.

The provision of unskilled persons for such jobs may be estimated at 10% of the skilled hands provided in the shops.

It may be also essential to indicate that planning of a programme of repairs etc., should be assigned to a separate Planning Department generally attached to the large-sized workshops. This work has to be necessarily done by qualified Engineers who have a sound practical background of workshop processess and adequate technical training regarding programming and scheduling of work. In addition, they should also have extensive experience in the field of maintenance and repair work in relation to plant and equipment in use on the job. Detailed planning by such planning group would reduce the incidence of emergency work being thrust upon the shops.

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10.9.2.2 *Emergency maintenance and repair work*

The emergency maintenance and repair work would involve minor repair jobs or major repair jobs. This may occassionally be in the nature of replacement of components on the machine—using standby components already lying repaired in the shops.

The requirement of personnel for this type of work may not always be possible to assess precisely. However, an extra provision to the extent of 10% of the requirement of staff as provided under planned maintenance and repair work may accommodate this additional requirement of personnel.

10.9.2.3 *Preventive maintenance*

The number of persons required to carry out the preventive maintenance work would largely depend upon the number of machines in use at any location or worksite or on the total operational activity as a whole. Their main activity is to keep a close watch on the performance of individual machines so that at the time any defects are noticed in any components/systems of the machine or malfunctioning of the machine as a whole is observed, a clear analysis could be made of the causes contributing towards such a condition of the components/parts/machine. Corrective actions to be taken as a result of such inspection/observation would include adjustments, replacement of parts/components, attending break-downs of minor nature and finally the act of repairing and overhaul of machines whenever necessary or at periodic intervals-as per practice in vogue.

The main objective for the preventive maintenance staff is to minimise down-time of machines and to ensure maximum availability.

To quote an example, we may refer to the case of an excavator in which few wires in some of the strand of the hoist wire-rope had got loose/dislodged from the main strands/wire-rope. If corrective action is not taken in time to replace the wire-rope (unless it can be conveniently repaired) during the maintenance time, it is likely that the wire-rope would snap when the machine is engaged on production. This would entail loss in production time which may be of the order of half-an hour to one hour, if not longer. Why lose this production time? Why not replace the wire-rope when, the defect is noticed by the maintenance team? Many such examples can be quoted from the actual experience in practice.

Normally, the requirement of personnel for preventive maintenance work would be commensurate with the particular items of work team would be assigned to carry out. Adjustments regarding number of persons to be placed in the team would have to be done from within the overall provision of 1½ persons per machine for two shifts working; or 2 to 3 persons per machine for three shifts working.

10.9.3. *Maintenance equipment & Tools*

Little useful purpose is served by establishing a maintenance and repair organisation on a project unless essential facilities are provided. If this is not done, the unit is inefficient; and it is found that necessary work is either not carried out or is performed indifferently through the lack of the tools for the job.

Minimum requirements for a field maintenance organisation, servicing an average mixed fleet of plant, but capable of being varied to suit individual cases, are:—

(a) Fitting shop equipment, benches, vices, cup-boards, racks, portable drills and grinders, hydraulic jacks, crowbars, hand tools, etc.

(b) Lifting tackle-gantry type or mobile crane for workshop use, mobile crane for field use.

(c) Portable electric welding equipment, oxy-acetylene cutting and welding plant, brazing plant, forge.

(d) Stores for spare parts, files, chisels, taps, dies, grinding wheels etc.

(e) Pressurised lubrication/servicing equipment.

(f) Steam cleaning and highpressure working.

It should be emphasized that the foregoing represents the minimum requirements for an average field unit to be self-supporting under normal circumstances. The facilities on a very large project are very much more complete and the extent to which equipment should be provided depends entirely upon the type and duration of the project and the classes and concentration of plant. Each individual case must be worked out in terms of economic factors involved bearing in mind that it is usually false economy to under-equip-all ill equipped and/or poorly controlled organisation is likely to be an expensive liability. This subject has been elaborately dealt with in Chapter '11'.

Mobile service units and workshop lorries effectively add to the convenience of minimising the time involved in maintenance of individual machines when the number of machines in any location is very large and the work is to proceed continuously and uninterrupted in two shifts or three shifts operations or where the work spread is wide.

The equipment generally installed in a mobile workshop is as follows:—

Air compressors (for tyre inflation).
Small lathe machine.
Drilling machine.

Small hydraulic press.
A work bench with vices.
Grinding machine.
Hydraulic jacks.
Grease pump and containers.
Oxygen and Acetylene welding apparatus with gas cylinders.
Tools.
A rack for spare parts.
A generator to be driven from the power-take-off.

Choice of items from the above list can be made in making a mobile service unit to suit particular requirements.

10.9.4. *Maintenance Supplies and Spare Parts*

The maintenance supplies and spare parts make as important a subject for attention as the provision of equipment and facilities for maintenance work. Occasionally, nonavailability of a proper grade of lubricant, a filter, a bolt or nut or even a cotter-pin may handicap commissioning of a machine for production work. Some fastmoving spare parts or sundry items like fan belts etc., may also cause a similar handicap. If the proverbial saying: "A stich in time saves nine", has any meaning, such provisioning with meticulous care of maintenance supplies and spare parts has to be arranged.

The subject of spare parts procurement etc., which would include the maintenance supplies as well, has been dealt with in details in Chapter 4. A passing reference, even at the cost of repetition may be made to the selective choice of the spare parts, proper lubricants and scaling of the requirements.

10.9.5. *Maintenance-Functional Distribution*

In what has so far been explained relates largely to the importance of various aspects of maintenance, the personnel required to do the maintenance work, certain norms regarding personnel, facilities etc., etc. The significance of each item, of maintenance work has also been brought out. In order, however, to define the areas in which particular items of maintenance work would be carried out—in order that the maintenance procedures are better understood for effective control in execution, it may be necessary to indicate as to 'who', 'what', 'where' and 'how'.

The following chart would give a broadline of what is in view:—

	1	2	3
WHO .	The Division using the	Circle/Unit in overall control of equipment.	Base Work shop Unit
WHAT .	Inspecting, cleaning, servicing, lubricating, adjusting, minor replacement.	Inspecting major replacement, major repair support for formation under 1.	Inspecting major overhaul, complete rebuilding, support for units 1 and 2.
WHERE	At equipment work-site,; and field maintenance workshops.	Mobile workshops and field maintenance shops	Base Work shops.
HOW	Minor repair, retain in the division.	Major repair and return to the division.	Rebuild for further final distribution.

10.10 *Additional considerations*

In addition to defining the areas and functions of maintenance, it may also be necessary to mention a few other points which will define the procedure of maintenance so as to set the maintenance work at a sound footing. Few important points are listed below with brief explanations.

10.10.1. *Technical manuals*

The maintenance staff and operating crew generally avoid reading the manuals published by the manufacturers of equipment. In fact, some of them do not have the basic qualifications to clearly understand the technical bulletins. It may be a good idea to prepare small leaflets or wall charts highlighting some of the important points to be observed by the operating and service crew. These should be in bold print and in a language which is clearly understood by all concerned.

In so far as the supervisory staff are concerned, they should normally be expected to read and understand the technical manuals. Since they are the persons to rigorously and methodically introduce the procedures for maintenance, duty as such should be assigned to them.

10.10.2. *Technical Bulletins.*

Certain service instructions get changed from time to time. The organisation authority—the supervisor-in-charge is the first person to know about such changes. Such changes should be brought to notice of all concerned again in the same manner as in the case of technical manuals.

10.10.3. *Lubrication Chart*

A lubrication chart is generally prepared in relation to each make and model of machines in use, on any operational activity. However, there may be some common items to be indicated in relation to different machines where the type of lubrication and the periodicity of servicing is identical or similar. Such information may be precisely spelt out in a wall chart or a board displayed at a suitable place in the maintenance shop, in the mobile service unit etc.

It may be a good practice to print the required details of lubricants, specifications etc., in individual log books which are always carried on each piece of equipment.

10.10.4. *Worksheet for Maintenance Service*

Printed forms for preventive and scheduled maintenance work on various machines should be made available according to pre-determined periods—weekly, fortnightly, monthly, or 50 hrs., 100 hrs., 250 hrs., 500 hrs. etc. A few sample forms used by some major users of equipment is given as Appendix 10.1.

In relation to inspection work, separate preventive maintenance service work-sheets should be available on weekly and monthly basis and for quarterly technical inspections—assuming that at least one major technical inspection of each piece of equipment will be carried out once in 3 months.

It is to be stressed that such worksheets should be as detailed as any item of work would warrant this to be; and care should be taken to provide blanks where the results of inspection can be figuratively recorded and not in terms of some yes or no. It is a common practice (based on observations of the Committee during their visits to work-sites in different areas) that the inspection reports are completed by some persons in the supervisory cadre while sitting in the office. If figurative information is to be clearly detailed in the technical inspection work-sheets, the supervisor would at least have to make the effort of physically inspecting the machine in all areas to which the information on the work-sheet relates.

10.10.5 *Feed-back of Information*

The technical inspection work-sheets should not be a matter of creation of records as a matter of routine of details. All important observations or remarks made by the inspecting officer should be communicated to an appropriate authority—generally the Base Workshops Superintendent and the Field Workshops Superintendent, or the Service Manager, so that he may issue suitable instructions for carrying out preventive measures or corrective measures to guard against future break-downs. Wherever necessary, as a result of remarks or observations made by the inspecting officer, the machines could be withdrawn from the operational area and necessary repairs/modifications done in proper time according to a phased programme which might be prescribed by appropriate authority undertaking such repairs.

10.10.6. *Transport Facilities*

Breakdown maintenance and repair work occasionally, if not very often, involves carriage of equipment from site of work to field maintenance shop, or base workshop depending upon the type of work involved and the facilities provided to handle the same. For this purpose, therefore, it is very essential to have transport units—trucks, truck-tractor-trailors, or semi-trailors for transporting the heavy components and equipment to the particular repair shops.

10.10.7. *Communications*

When reduction in downtime of equipment due to breakdowns etc., is the main objective before the maintenance organisation, it is necessary that the information regarding breakdowns or any emergency repairs to be carried out is passed on to the maintenance/service organisation without any avoidable loss in time. On construction jobs and in mining works where the motorised equipment is spread over a fairly wide expanse of area under operational activity, communication facilities either in form of telephone lines, wireless sets or radio net work are very essential. The telephone lines would generally provide fixed terminals wherefrom such communications could be transmitted to particular fixed points at the receiving end. The radio communication system, however, is flexible in so much so that a mobile unit in a car, truck or other equipment provides instantaneous communication wherever it may be. This means literally finger tip control over operations from the project office, from headquarters or any where in the field.

The direct benefits of such system of communication are:—

1. Control of flow of materials to the project;
2. expedition in transport of men and equipment;
3. quick despatch of parts and repair crew to the site of breakdown, thus reducing losses in productive time;
4. transmitting information regarding weather conditions etc.;
5. sending help expeditiously in the even of emergencies and accidents;

   and
6. exchange of information and advice in important matters requiring on the spot decisions with the help of superiors.

Such units are some times called "Walkie-Talkie" Radio Units.

Tele-type and telegraph equipment also becomes useful and beneficial, like the telephones, wherever and whenever information is to be urgently transmitted to locations which are very far from the operational activity area distance-wise. Transmission of progress reports and any other information relating to aspects of management control can be facilitated by such communication equipment.

10.10.8. *Forms in use*

Only a few important forms in relation to working of equipment have been considered for being prescribed in this report. Some others have already been prescribed in the First Construction Plant and Machinery Committee Report. Though it may help to prescribe the whole set of forms which any equipment user may use for creating records of inspection, maintenance costs of repairs etc., etc., it is commonly observed that the standard practice instructions issued by individual project authorities prescribe certain forms to meet the local accounting rules and procedures etc. Hence, so long as the main purpose of itemised information being checked and recorded is followed, the form for creating such records may not make a rigid pattern of enforce. Clear indications have already been given in various chapters of this report regarding the particular items of information, both relating to technical aspect of work with equipment and the cost aspect regarding operation, maintenance and repairs etc. The proformae that may be adopted should meticulously be planned so that all these items of information are suitably covered thereby.

In order to have an effective preventive maintenance system it is necessary to establish history records of each machine. The records of break-downs, the reasons for break-downs, cost of repairs etc. for each machine has to be recorded carefully in these history records. A set of proformae for maintaining the history records of equipment is given in Appendix 10.2.

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10.11. Summary of Observations and Recommendations

Even though there is evidence of better consciousness on part of the users of equipment regarding scientific approach to the work of maintenance of plant and equipment, the maintenance procedures followed by them relate more to the fulfilment of routine programmes. Generally prescribed by the manufacturers/suppliers of equipment, regarding oiling, greasing etc. The functional importance of 'Maintenance Engineering' in relation to plant and equipment is not clearly comprehended by an average user. The normal approach is of the type of 'After-the-fact-control'. More often corrective actions are taken only after the breakdowns occur. The concept of preventive maintenance is not properly practised.

Though everyone has accepted the main objectives viz. optimum utilisation, maximum productivity, least down-time and minimum cost of production as the main attributes of an effective maintenance programme and procedure, the existing organisational set ups at most places are not adequate to meet these objectives. Training programmes, inspection, preventive maintenance, provision of equipment and facilities for repairs and maintenance, proper inventory of materials and spare parts, work-study programmes and record keeping about performance data, cost evaluation and defect analysis are not well organized. Most often the consideration is to have short-time gain through reduced investment and expenditure on a well organised maintenance establishment. This is a false economy.

The importance of well maintained haul roads, provision of hygienic conditions and healthy environments for work also do not exist even where these are vitally essential. Dispensing of POL item is one area where hygiene plays an important role but is noticeably neglected by an average user of equipment.

Standardisation of petroleum products which makes the works of maintenance personnel simplified is not given the prime consideration, it deserves.

The records created for consumption of POL items, materials, spare parts, history of break-downs and repairs etc. are not generally analysed to the extent of making a useful cost evaluation, defect analysis and cost effectiveness.

For the maintenance work to be effective from stand point of economy it is necessary to formulate the procedures on pre-planning basis so that all necessary aspects of maintenance engineering are fully covered in relation to the particular plant and equipment to be maintained.

Recommendations

1. The work of maintenance of equipment should be assigned to a senior well-qualified and experienced officer who is fully acquainted with the machines to be maintained. The organisation under his charge should similarly include experienced and skilled hands.

2. For preventive maintenance and inspection work, the responsibility should be assigned to another senior officer, so that he can pursue a properly planned programme of inspection of machines at regular intervals, record his observations precisely about the wear and tear of the components/parts, take timely action for obviating breakdowns of equipment by timely adjustments in mechanical systems, make a timely forecast of requirements of spare parts and materials for the periodical overhauls and major repairs and through proper analysis of the information and observations recorded, devise methods and recommend measures for reducing the frequency of repetitive types of breakdowns or faults.

3. Senior Operators with long-standing experience in operation of the machines on the job, if employed on maintenance work would ensure the maintenance being done in a proper manner.

4. In-service-training programmes for training of maintenance and repair crew should be organised.

5. Hygienic conditions be created not only by keeping the machines clean but also for the repair and maintenance work to be done so that introduction of dirt into mechanical systems/parts and in the lubricants, oils and greases, ruins the machines and causes premature wear and tear, is avoided.

6. Maintenance of haul roads should be given special consideration as this would reduce the overall burden of maintenance of the machines by reduced incidence of breakdowns directly resulting from badly maintained haul roads.

7. Proper record keeping should be organised. This should be properly looked after by senior persons—engineers and should not be left entirely to the clerical staff.

8. A minimum number of brands and grades of greases and oils should be put to use for the lubrication of various machines at the site of work.

9. Necessary tools, adequate facilities and equipment should be provided for reducing the time for maintenance of individual machines. This would ensure better availability and more production.

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CHAPTER 11

ORGANISATIONAL SET UP INCLUDING WORKSHOP FACILITIES, STORES, WAREHOUSES ETC.

11.1 Introduction

The equipment maintenance and repair facilities as a part of the total operational requirement of an activity—construction of dams, canals, roads or development of Mines, ports etc., include workshop facilities, warehouses and stores. Whether motorised equipment is involved or plant installations, the provision of facilities as such is most essential for success of operations.

This Chapter will present the basic understanding of maintenance facilities and the fundamental considerations necessary to meet the varied requirements of work with equipment relative to different activities.

After the basic facilities and fundamental considerations have been fully defined, reference will be made to the pattern of the existing establishments in this respect with various major users of equipment in different sectors.

11.2 Organisational Set up

Before a major activity involving intensive use of large fleets of equipment and plant starts, preplanning decisions are taken with regard to the type of maintenance of equipment that will be introduced on the job. The organisational set up takes shape accordingly, to meet such requirements based on the preplanning decisions.

Such organisation may relate to centralised maintenance and/or area maintenance, or a combination of both and its final shape will, therefore, largely depend upon the corresponding maintenance facilities required.

Decision regarding centralised maintenance, area maintenance, or a combination of both, would again depend upon the spread of work on which the equipment is employed. If it is a concentrated work, in a location where suitable space is available centrally, to look after the maintenance requirement of equipment, and the magnitude of work involved is comparatively smaller, central shops may be more practical to cater to the needs of maintenance. However, if the work involves diversified sections or functions, as is generally the case with construction of dams and in mining areas, an area maintenance system supported by centralised shops, may be more practical. A general outline of the facilities necessary for both systems will, therefore, be given.

With the maintenance and repair facilities, the store room or warehouse facilities have also be planned as the maintenance work involves greatest need for accessibility to maintenance supplies—spare parts, lubricants, hardware materials etc., etc. The warehouse facilities have to be, as far as possible, so planned as to adjoin the section of the maintenance shops. Planning of the warehouses is also to be as meticulously done as the maintenance and repair facilities. The main idea is to avoid exhorbitant costs in handling of materials and to minimise travel time and distance in delivery of materials from the warehouse to the maintenance areas. A general outline of fundamental considerations in this regard would also be furnished in this Chapter.

11.3 Maintenance and Repair Facilities—Relative Considerations

The size, shape and extent of maintenance facilities are contingent on the general plan of work or activity involved, the location relative to outside facilities—accessibility by road, rail and other modes of transport, and also to the available capital to be invested in such activity. The type of construction for workshops etc., is mainly dependent upon the climatic conditions and sometimes by individual preferences—architectural considerations, for instance.

11.3.1 *Climatic Conditions*

The climatic conditions which play the most important role, not only provide the basic consideration for protection of equipment and personnel employed on maintenance and repairs, but also the basic provisions necessary for the work to proceed unhampered under a roof without the sensitivity resulting from dirt and dust, heat and cold, rain or strong breeze etc. The skilled maintenance workers can work most effectively in a comfortable environment only. Hence, the basic consideration is also to be related to the climatic conditions of the area where such facilities are to be organised.

11.3.2 *Size of Maintenance Facilities*

The second most important consideration in determining the size of the facilities for maintenance and repair is that relating to the extent to which the maintenance work will be done on the activity as a whole. This is generally termed as "Self Maintenance". It has to be decided initially, at the time of commencement of an activity, whether it would be economical to carry out all operations involved in the repair and overhaul of equipment, parts, components etc., within the workshop to be organised or that, assistance in this respect will be taken from some outside agencies, who might have specialised in certain type of works. Sometimes, minimum self maintenance is most appealing to short-lived activities—for example, in case of Projects of short durations of 3 to 4 years, involving limited capital. Yet another time the limited maintenance skills available on a given activity also lead to the consideration of availing good outside facilities for assistance in the work.

11.3.3 *Self maintenance*

This implies the 'Do it yourself' concept.

Generally speaking, the decision with respect to degree of self-maintenance can be taken based on the following factors:

1. Location of the job or activity—whether the place is accessible by rail, road and other modes of transport whether any service facilities and parts depots etc., of equipment distributors or other agencies are available near at hand.
2. Skilled labour—the lack of skilled manpower may provide the biggest handicap to 'Self Maintenance' programme. This no doubt, can be overcome by extensive and expensive training programmes. If, however, the maintenance help can be available from outside, one may consider to reduce the investment in facilities and get the maintenance help from outside agencies.
3. Capital cost—the cost of maintenance buildings, tools and equipment, is generally high. From economic standpoint, a judicious decision may have to be taken in making the capital investment in the maintenance facilities in such cases. By and large, however, with large outfits of equipment working on given locations, the investment on such facilities may range from 5 to to 10% of the cost of equipment and it may be prudent to establish such facilities as it would be cheaper in the long run to provide for maintenance facilities in this manner instead of utilizing the outside sources for this purpose.

11.3.4. *Centralised and Area Maintenance*

The concept of centralised maintenance and area maintenance finds an extended application to the case where a large number of small-sized projects are undertaken in a particular area or in a State, in a particular sector. For example, numerous medium sized or smaller projects in irrigation sector in different States are not in a position to organise maintenance facilities individually for 'Self Maintenance'. The major work of repairs to machines and components in such a case is to be centrally controlled while some field repairs and minor repairs are done individually on the projects where the machines are employed. The overall control is under a Central Mechanical Organisation in the Irrigation and Power Sector in the States. Central Workshops, Regional Workshops and Field Workshops are organised at suitable locations to cater to the needs of maintenance and repair of the equipment working with these numerous small sized projects. In addition, mobile service units and repair units are deployed to help the users of equipment in emergency repairs, or to expedite the repairs of machines under breakdown.

Smaller organisations for area maintenance are also created and established in relation to mines of smaller size where a large number of such mines are located in a given area under the management of one owner.

11.4 Maximum Self-maintenance—Considerations for Essential Facilities.

In making a general assessment and study on various aspects incidental to the use of construction plant and equipment with major users of such equipment in the country, an attempt has been made, in what follows, to present an outline of maintenance facilities from maximum "Self-Maintenance" point of view. The individual projects can be selective at the planning stage of the work as to what facilities would be desirable and most essential for their particular needs.

11.4.1 *General Shop Design and Construction*

11.4.1.1 *Shop site location*

After determining the size and scope of maintenance for a given activity in relation to particular jobs, the most important consideration is the shops' locations for either centralised shops or area maintenance shops.

The problem of site location is basically a compromise of (1) convenience to operations; (2) proximity to area of operational activities with equipment; and (3) drainage system. In fact, the drainage system comes to be a matter of outstanding priority while the other two considerations rank number (2) and (3). Most often, this fundamental aspect of drainage is not given the consideration that it deserves in view of other convenience and initial cost. Poor drainage design can seldom be corrected satisfactorily at a later stage and therefore, this must be given the prime consideration it deserves.

The Committee have noticed that in certain areas some of the shops were located at foot-hills and the floor area was found flooded during the rainy season. The drains alongside foot-hill were choked with a single heavy shower and the water could not be drained in spite of pucca drains having been planned initially. This handicaps the normal work in the shops during the off-season period when the repair work is the heaviest during the year.

In respect of convenience to operations, the shop facilities should be central to operations. A view on this can be taken properly by determining precisely the areas of operations in a given activity. In relation to work on a construction project—construction of dams, canals or roads, this can be more easily determined. In relation to work on the mines, however, various other considerations also arise, e.g. stripping waste piles, and ore limits. A shortsighted view on a new operation may result in serious errors either resulting in expensive shops being replaced and moved to new locations; or else, long term inconvenience would have to be borne because of the shops being located too close to the initial mining operations.

Proximity to operational installations is also equally important as travel time and transportation costs prove to be fairly costly. The Central Shops which provide a day-to-day service for the area maintenance shops, if located too far away, would result in loss of production time and extra transportation costs. One main consideration of course, is the proximity to rail head, existence of main roads for transportation by trucks. This in fact, is the most fundamental consideration in determining the location of any shops; and in case such 'Rail Heads' do not exist or access by road is also non-existent, these have to be provided for to the extent warranted by the work. In any case, access roads have necessarily to be provided.

Two more considerations have to be borne in mind in planning the location of shops. These are: (1) Storage; and (2) Expansion. Whether it is a mining, or a tunnelling job, or construction of a dam, the haulage equipment would require a dead-line area for storage prior to entering the shops. Similarly, other equipment like dumpers, tractors, scrapers, would require parking space prior to entry in the covered shop floors or after repairing. It is conventional to provide one half to one-third the area equivalent to the fleet size, either inside the workshops compound or in an outside enclosed space with a hand standing shed.

With regard to the aspect of expansion, certain amount of flexibility has to be provided in the basic plan of the shop areas, so that if expansion of the shops become necessary at any stage of the continuing operational activity to meet extra load of work due to revision of the production programmes etc., no inconvenience is suffered in meeting such requirements at short notice. After all, lay out of a workshop is the expression of a purpose. With the purpose gradually getting changed in shape and dimensions, the requirements may be fulfilled according to revised dimensions and framework of the purpose.

11.4.1.2 *Type of building construction*

The most common building material for shops is the structural steel over reinforced concrete floors. Steel has a good weight-to-strength ratio. It can be readily fabricated to given shapes and dimensions, can be made corrosion resistant, besides its adoptability to architectural needs. It also works well in combination with other materials, such as concrete blocks, bricks, and panelling material, to suit the architectural design.

In some cases, where it can be easily envisaged that on completion of the construction work on a project, the facilities created could be commercially used on permanent basis, masonry structures may be decided upon for shop construction. The initial high cost and sometimes lack of skilled masons in the area where the project work is to begin, may afford a handicap or a disadvantage. Sometimes, if the shop buildings are to be near the operational activity area—specially in mines, the work hazards—blasting etc., may cause severe maintenance problems for the buildings. Moreover, this type of construction does not easily accommodate future expansion or remodelling programmes. Besides, the handling facilities generally required to be provided in such shops—overhead cranes etc., may not be conveniently accommodated unless the likely expenditure involved is of no consideration.

The only advantages in relation to masonry structures are the excellent architectural effects that can be obtained in such structures and the low upkeep cost of the buildings.

In making a proper choice of the ultimate type of construction, due consideration has also to be given to the type of materials used—specially for the roof of the structures. In tropical conditions as obtaining in India, consideration is to be given in relation to particular locations, to the intensity of heat as a result of day temperatures intensity of rain-fall and in certain high altitude areas, the snow fall conditions etc.

In hot dry areas, the problem of heat transmission through the roof assumes serious proportions.

In desert areas as obtaining in Rajasthan, where the Rajasthan Canal Project work is going on, the dust storms keep raging unabated for continuous periods of 2 to 3 weeks at a stretch. To avoid dust and dirt in the shop area and yet provide proper ventilation for convenience of the personnel working in the shops, the shops are to be of enclosed type. In such circumstances, asbestos cemented sheets would provide protection against dust and heat. In most of the other places, corrugated galvanized steel sheets are in use.

In areas where there are heavy rains, the shops have to be similarly enclosed with floor areas fairly above the road level.

Basically, in making a choice of the roof materials particularly, the life cost of a roof will be determined by the degree of consideration given to the problems indigenous to the locale. Besides this, functioning of the roof for many years relatively maintenance free, is also to be considered. It is often said that a poor roof is a constant harassment and a costly investment. Hence, due consideration is to be given to the type of roof to be provided over the shop structures.

11.4.1.3. *Shop floors*

It is rather unfortunate that very little attention is paid to the floor design even though shop floors are the most "worked" part of the shop itself. Except for special areas, most floors are of poured concrete. Concrete for floors requires the best of materials so as to be of hard, abrasion-resistant quality when construction equipment and components have to be constantly on the floor.

If the shop floors are poorly made, it is impossible to keep hygienic conditions prevailing in the area, where the equipment is to be handled for repairs. Sometimes, the finest floor is provided over a poor subgrade. In such a case, the floor gets crushed and crumpled very soon. Hence, it is to be ensured that the fill (forming the subgrade) should be compacted to 95% of standard optimum compaction and should be capable of supporting the floor loads.

In respect of wear surface of the floor, it may be necessary to use special chemical hardners at times, so that the concrete used may provide dust-free surface.

It is also important to bear in mind that provision for trenches and drains has to be made in the initial plan of the floor layout. All utilities, such as water, air, electrical cables, exhaust piping, should be appropriately located in the layout plan and trenches etc., provided suitably when the floor is being constructed.

As also stated above, provision of adequate drains should be a matter of special concern. Skimping on the size or number of floor drains, is poor economy and will adversely affect housekeeping efforts as well as economy.

In special cases, where crawler track equipment is to be brought into the shops, it is necessary to embed old used rail pieces inside the floor, slightly projecting above the floor surface. The gauge of the crawler tracks has to be kept in view in spacing of such embedded rails or steel.

If properly designed and poured, a good floor will last the life-time of the building. Hence, the above-mentioned factors should be taken into careful consideration at the initial stage of construction of the shops.

11.4.1.4 *Overhead cranes, mono-rails and other handling facilities.*

Almost every maintenance shop requires the use of an electric overhead crane to be efficient. The size of the crane is to be determined by the heaviest piece to be handled. The type of control for the crane is again dependent upon the type of its. usuage in the shops. In large shops, the best advantage is obtained from cranes equipped with pulpit and controls. In others, the pendant-cable-controlled crane is cheaper initially and requires no operator. This type of crane works well for most of the shops, except where the shops are of a very large size.

Certain shop functions are best served by jib cranes, covering the area within their radius, thus conserving overhead crane time. These can be provided with manual/electric or pneumatic hoists. However, planning for installation and provision of such cranes is necessary at the initial stage of the shop layout.

Mono-rail cranes are also sometimes used. These, however, have limited application as these are effective only when one route movement is possible. These are not flexible, but can be used to transfer materials from shop to shop or from shop to outside or even from crane to crane. These are also popularly in use mainly when assembly work is involved.

Expenditure on handling of materials at times mounts as high as 40% of the total cost of work in a shop. Meticulous planning of the layout of the shop is therefore, necessary, so that handling of materials is reduced to the minimum possible through provision of handling aids and in providing proper sequence of operations for given jobs by installation of the machine tools in a certain order as a function of inter-relation of machines inside a shop and intra-relation of machines in different shops.

For convenience of transport of equipment under breakdown at worksites to the area maintenance shops or the central maintenance shops, it is also necessary to provide suitable truck-tractor-trailors, or heavy duty trucks or semi-trailors etc., together with mobile cranes for loading and unloading of such equipment. This is a very essential adjunct to the main items of equipment and facilities provided in the workshop area.

11.4.1.5 *Storage*

In order to afford the convenience of work-space for the personnel engaged in the shops, it is most essential that the work areas are not clustered. Good house-keeping of the shops can be accomplished only if storage space for materials is provided. Spare components, rebuilt parts, special tools etc., must have floor space. Out-door storage space would no doubt, be less expensive, but least desirable, in view of the handling costs that would be involved besides the deterioration that such materials may suffer when exposed to the hazards of heat, cold, dust, dirt, etc. etc.

Normally, the size and space requirements can be anticipated at the stage the shop planning is being done. Stands, racks, cabinets and shelving can be provided for most efficient use of the storage space in the work areas.

11.4.1.6. *Offices and wash-closets*

No shops can work without an adjunct by way of office where records are compiled in respect of work done in the shops both with regard to cost of work being done, and the processing of the jobs. It is but necessary that such an office in the workshop premises must be a comfortable place to work for the supervisory staff and the clerks. Such offices should be central to the shops, should have sufficient space to accommodate personnel during small meetings, should have an independent entrance from outside the shop floor area and the extent possible the ceilings should be of acoustical material. If it is possible to provide a difference in level of the elevation of the office floor above the shop floor, the supervisory staff can have the privacy besides the facility to supervise the work even when in office, specially when the office overlooks the shop floor area.

With regard to wash-rooms, this item is generally not accepted as contingent upon the main-requisites of workshop planning. All the same, a well-designed and centrally located wash-room can reduce loss of time in the shop. In big workshops, circular wash fountains provide space savers and are easy to clean.

The size of the wash-room has to be determined by the maximum number of employees per shift.

11.4.1.7 *Out-door storage and materials handling*

Sufficient out-door space is to be provided for storage of heavy, bulky materials, such as steel plates, beams, rounds, pipes etc., which are the basic materials generally processed through the shops where construction plant and equipment is intensively in use. Besides the storage space the convenience of handling such heavy materials has also to be properly planned and provided for. Yard cranes and trucks are required to handle and move the materials. Hence, there should be sufficient clear space between stacks of such heavy materials.

Provision of small farm-type tractors makes a good asset as the materials can be dragged from the store yard to required locations where this is to be used. The same tractor which has a fairly low initial cost-tag on it, can be used in conjunction with trailers fitted with draw-bar, for movement of materials into the storage space or outside.

11.4.1.8 *Space needed for equipment repairs*

The space needed for equipment repairs depends to a large degree on the following factors:—

(1) Extent of repairs to be performed: i.e. whether certain types of repairs are to be done in the area maintenance shop, or in a higher level shop—central maintenance shop, or even by a group of travelling mechanics on a mobile service unit.

(2) Extent of work to be assigned to commercial shops.

(3) Number of major units of equipment, specially motorised types which are to be maintained and repaired in the shops;

(4) Types of equipment in use; and

(5) Effectiveness of preventive maintenance programme in minimising major overhauls.

It has been indicated previously in Chapter No. 10 "Maintenance Procedure", that the floor space to be provided for each unit of major equipment varies from 150 sq. ft. to 180 sq. ft. in the main repair shop; and from 100 sq. ft. to 120 sq. ft. in the field repair shop. A proper compromise has to be made keeping in mind the above-mentioned factors with regard to the total floor space to be provided in the area maintenance shops and centralised maintenance shops relative to given operational activity where equipment is in use.

11.4.2 *Repairs to Equipment—Classification*

Another consideration that seems important is the equipment maintenance and repair methods. For purposes of analysis, equipment repairs may be classified into the following major categories.

11.4.2.1 *Minor repairs*

Minor repairs are made at field repair shop level, and usually consist of replacement of a few individual parts, or reconditioning of some assemblies when such work does not involve the use of highly specialised equipment, or tools. Relining brakes, grinding valves, replacing king-pins and bushings, replacing broken springs, bleeding hydraulic systems, minor electrical systems repairs, are typical of such jobs of minor repairs.

11.4.2.2 *Unit replacement*

Unit replacements are also made at the field repair shops. Functional assemblies, such as generators, radiators and oil coolers, water pumps, differentials, motor assemblies track chains for crawler tractors, turbo-chargers. super-chargers/blowers, etc., are replaced as a unit. This is mainly with a view to minimising the amount of time lost by both equipment repair and operating crews, and is seemingly a mandatory requirement for any efficient fleet repair system as of the present times.

11.4.2.3. *Major repairs*

The need for major repairs is usually determined as a result of periodical inspections when mechanical characteristics, such as engine compression and wear of parts and units are measured. The inspectors determine the need for major repair work against a standard of allowable tolerances and wear. Experience has shown that the wear on certain moving parts necessitates rebuilding or replacement after a fixed period of use. Accordingly, major overhaul becomes almost automatic after a pre-determined number of hours of operation/use or a fixed mileage is reached. This is a part of the preventive maintenance exercise, which enables the inspectors and the owners of equipment to lay down a programme of overhaul or major repair of equipment, in terms of fixed periods of time in relation to particular category and type of machine in use.

11.4.2.4. *Repair activity—a functional approach*

A noteworthy characteristic of the large repair shops, which are operated by Public Sector organisations or Government Departments, is the organisation of repair activities by Departments. Under this system, a unit of equipment that is in need of a complete overhaul, can be torn down and the various assemblies assigned to shop subdivisions, so that all necessary repairs can be accomplished concurrently, thus saving the time involved in recommissioning the unit of equipment undergoing major repairs.

On construction jobs involving the use of heavier types of eqpuipment, where it is also necessary for the major repairs to be carried out at the project level, functionally designed mobile repair shops, mounted on trucks and equipped with a full complement of tools and a power generator for operating common items of tools, like grinders and drills, help in carrying out repairs at site of work in the field.

11.4.3 *Centralised Maintenance—Shop Plan For*

So far, items of common consideration relative to centralised maintenance area maintenance, by way of shop buildings, handling facilities, shop floors and repair activity etc., have been clearly covered. The facilities specifically and separately related to centralised maintenance and area maintenance works, have to be further identified on functional basis.

The nature of work in the shops for centralised maintenance could be classified as 'general maintenance and repairs' and would be of multipurpose type including, besides the major repairs to equipment, substantial amount of manufacturing processes, consuming a good deal of raw materials. The area maintenance work would, however, encompass specific requirements of installed plants' repair and maintenance, in locations contiguous to the installations and also cover the field maintenance and repairs of minor nature in relation to motorised/mobile equipment, in suitable shops at the work-sites.

A typical repair shop plan layout relative to centralised maintenance and repair work for 200 machines is given in Appendix 11.1.

11.4.3.1 *General maintenance and repair shops*

The work in general maintenance and repair shops may be sub-divided according to the functional requirements, keeping in view of the minimum time necessary for repairs to equipment. The shops may be planned in the following manner:—

1. Machine shop.
2. General repair and fitting shop.
3. Smithy shop.
4. Foundry shop.
5. Battery shop.
6. Heavy equipment repair shops—by individual categories of machines.
7. Diesel engine repair shop.
8. Electrical repair shop.
9. Drill repair shop (Mainly for construction work and mining activity).
10. Structural shops—steel fabrication works, including sheet metal shop.
11. Servicing section.
12. Wood working machinery shop (and body building shop wherever required).
13. Pain shop.
14. Tyre retreading shop.
15. Welding shop.
16. Miscellaneous machinery repair shop.
17. Transport & light vehicle repair shop.

11.4.3.2 *Heavy equipment repair shop*

In relation to heavy equipment repair shop, a further sub-division would be necessary in the following manner, as sub-sections or component repair shops:—

- (i) Transmission repairs.
- (ii) Hydraulic systems and hydraulic equipment repairs (including torque-converters).
- (iii) Differential repairs.
- (iv) Track group component repair shop.

11.4.3.3 *Engine repair shop*

In relation to the engine repair shop, further sub-division of work will be in sectional compartments relating to the following:—

- (1) Cleaning and degreasing section.
- (2) Disassembly and inspection section.
- (3) Cylinder-head section.
- (4) Supercharger/ Turbo-charger/ blower section.
- (5) Aircompressor and clutch section.
- (6) Electrical fittings section.
- (7) Assembly sections—one each for particular makes of diesel engines under repairs.
- (8) Dynamo-meter section for running in and testing of repaired engines.

11.4.3.4 *Specialisation—main purpose*

The main purpose of sectionalisation of work in the manner defined above is the specialisation, besides the saving in time, due to concurrent repairs of components and also to provide a means of supplying standby rebuilt components which would help in further saving of the time in repair and overhaul of the machines. While in some cases, it is generally necessary to repair and overhaul the particular components belonging to a given machine under overhaul, and commission the machine after repairs only with these components, it is a healthy practice to have standby components duly rebuilt, repaired and reconditioned, so that when a machine is under major repairs and overhaul, the rebuilt or reconditioned standby units can be conveniently switched to the chasis of the machine and the machine is sent out after being recommissioned in the shortest possible time. Such a practice is helpful, specially when certain machines breakdown during the working season, when certain production levels have to be achieved on the job and also when the repair and overhaul of a large fleets of machines is condensed into a brief period—off-season period of about '3' months. The limited space and floor area of the available shops, besides the limited period during which the repairs are to be completed so as to make the machines fit for the next season's work, make it mandatory for such a practice to be adopted to the best advantage of the equipment fleet owner and the work where the machines are to be used.

11.4.3.5. *Shovel repairs*

In relation to shovel repairs, it may be indicated, that the shop should have a pit into which the shovel can crawl. The ramp providing approach to the pit should have a smooth gradient of 1 in 16. Drainage arrangement for the pit must also be provided with a sump pump, pumping out water from a small drainage tank

सत्यमेव जयते

in one corner—at the farthest end opposite the ramp. The depth of pit should be such as to make the walking platform provided on the shovel to be flush with the floor area. This affords the convenience of repair crew and personnel walking across to repair the machinery portion of the shovel, while the shovel boom can be conveniently laid on the shop floor and attended to for repairs, if any.

Another advantage of providing a pit in the shovel repair shop is the saving in the height of the roof over the shovel repair shop which would otherwise normally have to be fairly large in view of the clearance necessary above the gantry on top of the shovel cab roof and the height of the boom sheave point.

The machinery portion of the shovel can be raised up with the assistance of hydraulic jacks of suitable capacity and finally rigged on sleepers scantlings or other suitable propping arrangements to clear the centre pintle or king pin of the shovel.

11.4.4 *Shop Equipment and Tools*

It will be too much to elaborate the details of the equipment that should be installed inside the shops for convenience of quick repairs to machines, as the exact requirement in this respect would have to be precisely related to the type and volume of work to be done in any shops. Hence, in what follows, the type of machine-tools and facilities generally installed inside the shops will only be described, so that a guideline is furnished by way of identification of the items of machinetools. Certain items like welding lines, compressed air-lines, centralised oxygen and acetylene systems, etc., which happen to serve most of the shops will be described in greater details.

Given below is the description of the items of machine tools and facilities generally provided in the particular shops against which these are mentioned. IT IS, HOWEVER, TO BE NOTED THAT JUDICIOUS SELECTION OF ITEMS—THEIR TYPE, SIZE AND QUANTITY, WILL BE MADE BY THOSE RESPONSIBLE FOR CREATING THE WORKSHOP ORGANISATION. THE ITEMS OF MACHINE TOOLS SO SELECTED, WOULD BE IN CLEAR CONSIDERATION OF THE WORK-LOAD, AND THE TYPE AND NATURE OF WORK.

11.4.4.1 *Machine shop*

1. Metal working lathe/s—3″ to 60″ swing and 'ways' length, as desired and necessary.
2. Planner.
3. Shaper.
4. Milling machine.
5. Drill/s including radial drill.
6. Boring mill—horizontal/vertical.
7. Power hacksaw/cold circular saw.
8. (a) Grinders, pedestal, portable and tool post grinders.
   (b) Tool grinding machines, cylindrical grinding machines, surface grinding machines.
9. Portable line boring bar-powered bored equipment used to line bore parts too large to set up in machines or which must be bored in the field.
10. Presses-arbor and hydraulic to press fit assemblies or to remove parts which are tight-fits. The hydraulic press may be vertical or horizontal and may range from 50-Tons to 200 Tons capacity.
11. Tool room equipment.

The machine shop requires a great variety and sizes of cutter, drills, reamers etc., for its work. Sufficient space has to be provided for storage and repair of all such tools which are fairly expensive.

It is also customary for the tool rooms to repair and store small power drills, such as portable drills, impact wrenches, hydraulic jacks etc. Work benches, special tool grinders and precision bench lathes are also necessary for a well-equipped tool room.

Occasionally, a small heat-treatment furnace-electrically operated, is also necessary to make the tool room selfsufficient for its needs. If an elaborately organised heat-treatment section is available separately as a part of the general shops, the heat-treatment work for the tool room jobs is got done in that specialised shop.

11.4.4.2. *General repair and fitting shop*

This is an extension of the machine shop and the machine tool facilities provided in the latter are utilised for the work in hand. Besides this, functionally, the general repair work involving fitments etc., is done through a host of fitters employed on work.

The machine tools required exclusively for this shop may comprise of the following:—

1. Press
2. Grinders.
3. Mechanical/air-operated power tools-impact wrenches etc.

The general repair and fitting shop personnel are also engaged in attending to the work arising in the area maintenance shops or in the field.

11.4.4.3. *Smithy shop.*

1. Coal fired furnaces with blowers.
2. Oil-fired furnaces
3. Power hammers-air-operated or electrically operated-250 k.g. to 500 k.g.

11.4.4.4. *Heavy equipment repair shops.*

1. Arbor press.
2. Pedestal grinder
3. Pillar drilling machine
4. Machine lathe.

For crawler tractor repair shop, it would be essential to have the submerged arc-welding machines automatic types-special machines for track-chain rebuilding, track rollers and idler rebuilding, besides a track press, electrical/hydraulically operated and impact wrenches

5. Wherever welding lines are not available through a central arrangement, separate welding sets may be provided in each one of the heavy equipment repair shop.

6. For component repairs, separate stands for transmissions, differentials and hydraulic system components would be required. These would have to be specially fabricated.

Besides this, arrangements would have to be rigged up for testing of the repaired components, or for 'running-in-operation' thereof.

11.4.4.5. *Diesel engine repair shop*

1. Fuel pump test bench/s.
2. Injector testing equipment.
3. Injector-tip/nozzle testing equipment.
4. Valve grinding/refacing machine.
5. Cylinder-head, hydraulic testing equipment.
6. Honing equipment.
7. Lapping and polishing arrangement.
8. Line boring equipment.
9. Connecting rod alignment equipment.
10. Pedestal grinder.
11. Dynamo meter.
12. Engine stands.
13. Lathe/s.
14. Crankshaft grinder.

Besides the above equipment, some of which may be optional, depending upon the size of the job individually and the functional work done in the shops, a variety of tools are necessarily required to handle the work with precision and efficiency. These are as follows:—

1. Puller, gear (set).
2. Puller sleeve.
3. Radiator repair equipment.
4. Reamer, adjustable.
5. Reamer ridges.
6. Sander, electrical.
7. Testers, special, for valve spring etc.
8. Special vices for holding pistons etc.
9. Welding and cutting outfit-Oxy-acetylene
10. Blow lamps.
11. Micrometers
12. Torque wrenches.

With respect to fuel injection parts repair, it may be mentioned that the heart of the diesel engine is in the fuel injection system. To overhaul and calibrate pumps, governors and injectors, a dust-free, temperature controlled room must be provided. There are several basic fuel injection systems, each requiring special tools and equipment to properly repair and calibrate its components. Pump calibration stands, injector floor rating machines, injector pressure stands, lapping machines, air gauges and ultrasonic cleaning tanks for injector nozzles, are among the equipment needed.

It is not always necessary to have a separate fuel injection parts repair section in a main shop relative to a given activity, unless the population of diesel powdered equipment is fairly large having a few standard makes of diesel engines in use. Where the population of equipment is relatively small, it is customary to have the fuel injection components repaired by specialised organisations outside, who are generally named as "Factory authorised vendors/ dealers".

A special mention has also to be made about the 'Dynamo meters', which are used for running in of the engine, and for making any necessary adjustments, checking for leaks and determining the horse-power of the overhauled engine. There are two types of dynamo-meters in common use-the water pump and the electrical generator-resister. The high cost of the latter generally precludes its use, except for low horse-power engines.

A passing reference may also be made to the need for the installation of the dynamo-meter and engine stand in a sound-proof room, provided with necessary crane or a mono-rail facility for handling. Instrumentation is another necessarily essential part of this room. Provision must also be made suitably for fuel supply, water, air, waste-water drainage and engine exhaust.

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11.4.4.6 *Electrical repair shop*

This is more of an outfit for the electricians to rewind armatures, coils and repairs to commutators etc. Depending upon the type of the work decided to be done in a shop, the equipment may vary from job to job. Where large-sized motors and generators are undertaken for repairs, special machines would be required to suit the particular purpose. In an average shop, it is more of a cluster of electrician's benches with instrument panels for testing the repaired electrical equipment.

One of the main requirement of this shop is the insulation drying equipment, which again varies with the type and size of electrical machines under repair.

It is also necessary to have machine lathes with 10″ to 12″ swing and for armature turning, generator-regulator test stands.

11.4.4.7 *Drill repair shop*

Portable hydraulic jacks and rams and grinders and large impact wrenches along with Oxy-acetylene equipment and welding equipment are essential for this shop.

The compressors and electric motors or diesel engines generally used with the rotary and down-the-hole drills, are repaired in the respective shops—compressors in the miscellaneous machinery repair shop, electric motors in the electric shop and diesel engines in the diesel engine shop.

Automatic welding machines are also provided wherever the type of drills used are such as would require for such equipment.

11.4.4.8 *Structural shop*

1. Punching and shearing machine—power press.
2. Bending rolls.
3. Radial drills.
4. Oxy-Acetylene profile cutting machines.
5. Oxy-Acetylene automatic cutting machine.
6. Hydraulic press.
7. Welding sets/welding lines.
8. Girder bending and straightening machine.
9. Radio-graphic camera/X-ray equipment.
10. Pedestal grinder, double wheeled.
11. Pipe bending machine.

11.4.4.9 *Servicing section*

1. Hydraulic lift.
2. Air compressor.
3. Pressurised lubrication equipment
4. Washing stand.
5. Steam jenny.
6. Water tanks.

11.4.4.10 *Wood-working machinery shop*

1. Planning machines.
2. Band-saw.
3. Circular saw.

11.4.4.11 *Paint shop*

1. Paint spraying plant.
2. Drying chamber.

11.4.4.12 *Tyre retreading and repair shop*

1. (i) Rim Remover, (ii) Tyre expander.
2. Buffing machine.
3. Rubber cement spraying Equipment.
4. Building machine.
5. Mould with matrix.
6. Steam boiler.

11.4.4.13 *Battery shop*

1. Battery chargers.
2. Water spray.
3. Exhaust fan.
4. Distilled water plant.
5. Blow lamp.

11.4.4.14 *Automotive shop*

1. Hydraulic press.
2. Drill press.
3. Heavy duty pedestal grinders.
4. Jacks, hydraulic and air.
5. Wheel aligning equipment.
6. Spark plug sanding machine.
7. Electrical timing and tuning equipment.
8. Miscellaneous items of machine tools, according to requirement.

11.4.4.15 *Welding shop*

The welding machines may either be individual items like motor-generator set, or a transformer welding machine with single or multiple operator lines, or as in the grid system, a suitable capacity transformer unit feeding a number of regulators—each with single or double welding lines. In some cases, power is supplied to convenient outlets located at places where these are needed in individual shops and each outlet serves one welding machine. The building is grounded and provides a convenient ground circuit for any welding. For mobile equipment, a separate ground is carried to the work.

In the grid type arrangement, the grid resistors provide the controlled amperage and voltage. This eliminates the location of welding machines in the shop area besides eliminating the machine movement. If the grid location is so planned that the welding leads can be taken therefrom to convenient places of work in the shops, this can be an economical method to provide facilities for welding. However, in this case, the main control being at the grid location point, regulation of ampereage and voltage has to be manually done. This could be controlled by telephone communication system, or by the end user personally going and setting the regulator at the required point to give the desired ampereage and voltage.

In certain welding jobs, special electrodes are required to be used, and this involves entirely different equipment. Welding of zinc, aluminium and magnesium alloys which are extremely hard to weld, involves the heliarc welding machines.

Automatic submerged arc welding is also commonly involved, specially when rebuilding of parts or structural work is concerned. As an adjunct to this, welding positioners afford the convenience of proper positioning of the pieces to be welded at a fast rate. The positioners are generally powered either electrically or hydraulically.

Rotary tables, drive and tail stock, similar to lathe, roller positioners (for circumferentially rotating large work) etc., etc., are also some of the types of welding positioners.

The equipment as above, may be a part of the structural shop to the extent required and in certain cases, work in isolation in a central welding shop.

Trailor mounted diesel/electric operated welding sets and oxy-acetylene cutting and welding sets make another useful item of equipment to be provided. Certain welding jobs assigned to the workshop team in the field area can be conveniently carried out with the help of these mobile welding sets. Moreover, during the course of testing of machines, after repair and overhaul, such mobile welding sets are very useful in the vehicle parking area, in the "hard-standing" sheds or in the operational test fields.

11.4.4.16 *Compressed air system*

The requirements of compressed air may be for use of power tools, for cleaning of surfaces, for serving and paint sections, and for various other applications inside the shops. Depending upon the total activity involving use of compressed air, the compressed air system could be fed from a central location where a battery of compressors or a single large-sized compressor can be put to use. For particular types of works where the air compressor at the discharge end is necesarily to be of a certain rating, and the compressed air lines have to extend over a large distance from the central location, it becomes necessary to instal a separate air compressor for the particular location to meet such a situation. Overhead compressed air lines, or laying of the compressed air lines in drainages in the floor area, has to be initially planned in a suitable manner to meet the requirements of various activities all over the shops. Subsequent installation at times involves interference with other facilities which are already in use and this proposition becomes rather expensive and uneconomical.

11.4.4.17 *Centralised oxygen and acetylene systems*

Oxygen and acetylene are used in large quantities in maintenance work and in the structural shop where steel fabrication is involved. The most common procedure is to get Oxygen and Acetylene Gas in cylinder as supplied by the manufacturing plants. However, to make the operations economical, specially when the consumption of Oxygen and Acetylene Gas is fairly high due to the nature of operations to be performed, it becomes economical to purchase the gas in small tanks and distribute them to the shops as needed. Even this is quite a cumbersome procedure, as it involves to a slightly lesser degree, the same problems of handling distribution and collection of the tanks as in the case of gas cylinders. Besides, the arrangement for transport of the containers-cum-tanks or cylinders from the manufacturers to the users worksite can involve certain difficulties occasionally in transporting these containers to and fro. If the work at the users' end cannot brook such delays and the supply has necessarily to be continuous and regular, a central plant can be equipped to distribute Oxygen and Acetylene through a piping system to each shop, or by generating the Oxygen and Acetylene and bottling same in containers for convenience of the various user sub-divisions on the project. Not only is the gas produced at economical rate, its ready availability enables the user to keep up the work in good progress.

Such Oxygen and Acetylene manufacturing plants are of course, rare to see with individual project authorities. They are exceptionally few, who have provided such installations. Beas Project in the Irrigation and Power Sector is one such example to quote.

11.4.5. *Area Maintenance Shops*

11.4.51 *Purpose*

The main purpose of area/field maintenance shops is,

(1) to prevent mechanical break-downs of equipment as far as possible; and

(2) in case of mechanical break-downs to put the machine back into service with a minimum loss of time.

If a machine is not kept in a properly adjusted condition, it loses the performance efficiency and there is a tendency to unusual wear and tear on the machine. The prevention of mechanical break-downs mainly relates to such timely adjustments to parts and components in the machine. The main function of the area maintenance shop should be to provide for schedule of adjustments, indicating the intervals at which such adjustments are required to be checked and the time to be taken for adjustment. Regular mechanical inspection is also a part of this schedule through which the possibility of major break-downs are checked at the commencement of the smaller initial causes.

Minor repairs which cannot be scheduled also need prompt attention so that it may not subsequently lead to severe breakdowns due to negligence in carrying out the repairs in proper time. When, inspite of precautions, major break-downs occur at the site of work, the field maintenance personnnel should concentrate on returning the machine to work on the minimum loss of time. The methods of so doing depend upon the nature of breakdown, the type of machine, material facilities, labour facilities etc. Sometimes assembly and sub-assemblies replacement are also a part of the work to be done in the area maintenance shops. Immediate replacement of a defective assembly, than keeping the machine waiting for repairs on the defective one is more economical as the machine can be used on production work immediately on the replacement of the assembly.

The function of the field maintenance is to see that no machine is allowed to continue on work when it is in need of mechanical attention whether of relatively minor nature or of a more serious character. Prompt attention to minor faults, even if at the cost of stoppage of work, would pay in the long run.

11.4.5.2 *Location*

The area maintenance shops or the field shops take a part of the work in respect of maintenance and repair of equipment very near to the location of their work. The first consideration is that this should be located as near as possible to the scene of operation, with good access roads, to minimise the time to be taken in bringing plant to the workshop. In some cases, the installed plants—as in a case of the mining work (the typical example being a crushing plant), such maintenance shops have to be so arranged and located that speedy repairs to such equipment is facilitated. Moving heavy mantles of large-sized crushers away from the crushing plant to distantly located workshop premises may be not only a cumbersome procedure from transport and handling angle, it may also involve lot of delay in repair or reconditioning thereof. Hence in so far as the area maintenance shops are concerned, the main consideration, in context of convenience and speed of work of maintenance and repair of work is the sub-division of such operations into separate field shops for maintenance and repair of the mobile or motorised equipment and the installed equipment.

11.4.5.3 *Shop equipment*

Little useful purpose is served by establishing a field maintenance organisation on a project unless essential facilities are provided. Without facilities, the unit is inefficient; and either necessary work is not carried out or is performed indifferently due to lack of the tools for the job.

Minimum requirements for a field maintenance organisation servicing an average sized mixed fleet of equipment and plant are:—

(a) Covered workshop floor space, preferably on a concrete floor, provided with light and powerself-generated, if necessary.

(b) Workshop vehicle park.

(c) Fitting shop equipment, benches, vices, cupboards, racks, portable drills and grinders, hydraulic jacks, crowbars etc.

(d) Lifting tackle-gantry type or mobile crane for workshop use, mobile crane for field use.

(e) Portable electric welding equipment, oxy-acetylene cutting and welding plant, brazing plant forge.

(f) Stores for spare parts, files, chisels taps, dies, grinding wheels etc.

(g) High pressure washing equipment & steam jenny.

It should be emphasized that the foregoing represents the minimum requirements for an average field unit to be self-supporting under normal circumstances. The facilities on a very large project are very much more complete and the extent to which equipment should be provided depends entirely upon the type and duration of the project and the classes and concentration of plant. Each individual case must be worked out in terms of economic factors involved, bearing in mind that it is usually false economy to under equip. Ill equipped and/or poorly controlled organisation is likely to be an expensive liability.

11.4.5.4. *Motorised equipment.*

The area shops for the motorised equipment would mainly involve installation of a few items of machine tools-lathe, drilling machine, pedestal grinder, arbor press, welding equipment, Oxyacetylene cutting and welding equipment, pressurised lubrication and servicing equipment besides a large variety of hand tools and some power tools.

Here again, however, for certain categories of equipment—mainly the excavators slightly different arrangements would be required. The maintenance and repair shop in the field for this category of equipment, would have a smaller set up, as described in the centralised maintenance shops—providing a suitably floored pit under a roof shed necessary provisions of drainage arrangement, fitters benches and certain tools, including power tools. Of course, the handling facilities by way of lifting tackle, jacks and overhead crane, would entail efficiency to repair work for such equipment.

As a part of the area shops equipment, mobile servicing units are also required. It is customary to maintain most of the items of motorised equipment while these are on the run on production work. The mobile servicing units get parked at suitable locations in the work area and the machines are drawn one after another at periodical intervals for servicing or any minor repairs that may arise in the course of operation of equipment. Such units may be skid-mounted in some cases, or trailor/truck mounted. The essential items of equipment installed, whether mounted on skids or trucks/trailors, would be an air-compressor, pressurised lubricating or lubricant-dispensing units, with reels of hoses and accompanied by a trailor-mounted or trolly mounted miniature shop having a power unit with a drill and a grinder. Sometimes, a separate trailor-unit with essential hardware materials, like nuts, bolts, screws etc., is also a part of the mobile unit, to help carry out minor repairs to the equipment.

11.4.5.5. *Installed equipment*

In relation to installed equipment, like crushers, where crusher-mantle and concaves are prepared in the shop, mantle stands, zinc pots and zinc storage facilities are prerequisites. If the shop can be arranged on the crusher working floor, the major overhaul crane will serve the maintenance shop also. If this facility cannot find extended application as such, a separate overhead crane would be needed for this heavy work. If, however, the shop has to be separately located, it should be central to the plant operations and preferably on the ground level to facilitate handling of heavy items. In any case, this also has to be under roofed accommodation.

11.4.5.6. *Repair Stalls*

It is also a practice with some of the users of equipment, where large fleets of equipment are put to use on given activities, to have repair stalls in close proximity to the operational area. The size of such stalls can be determined by the size of the items of motorised equipment in use. Normally, the width and the length of the stall would be such as would afford the convenience of a motorised pieces of equipment to drive in and yet leave sufficient space on the sides and in front for the maintenance and repair crew to move around the machine and also to have the facility of a work-bench besides.

Yet in few other cases, the stalls take a different shape. These are in the form of fabricated steel structures with canopy on top and arrangements for lifting the structure provided at suitable place of the structure. If a machine breaks down in the work area, it is towed away to a convenient location therein closeby and the structure picked up with the help of a crane to provide cover and protection to the particular area of the machine in which the repairs are done. It may not be necessary to mention that such arrangements are peculiar only to such jobs where the climatic conditions or the day or night temperatures cause physical trouble to the working crew and specially when the repair or maintenance work would take a fairly long time.

11.4.6. *Servicing Facilities.*

In what has so far been considered in this Chapter, the broad outline of functions and layout of centralised maintenance shops and area maintenance shops has been dealt with. The main item common to both of these items is the servicing facilities in form of service station equipment. Whether a service station is fixed or mobile, the equipment is substantially the same and should include·

(a) Tanks or containers for all classes of lubricants, flushing and cleaning fluids, water and distilled water etc., with arrangements for drawing off without contamination.

(b) Air compressor plant for pressure greasing, air cleaning and tyre inflation, as may be required.

(c) High pressure water washing plant, petrol or diesel driven, for mounting on mobile plant or electric motor driven for service station installation.

(d) Steam jenny.

(e) Cleaning materials, preferably in lockers.

(f) Filling measures for each type of lubricant, specially service tools, grease guns, pressure grease buckets, spanners of assorted sizes and types, tyre gauges, puncture repair outfits etc., with arrangements to keep them clean and necessary provision for storage.

(g) An assortment of hardware items, including nuts, bolts, washers, grease nipples, split pins etc., in suitable bins and lockers.

Permanent fixed service station are GENERALLY provided with fuel storage tanks for direct dispensation fuel to the fuel tanks of individual machines or for drawing of supplies there from into a clean mobile tanks which may dispense fuel at mobile service station points or for the use of stationary plant scattered over the work area in the field.

Travelling fuel tanks to plant not readily accessible to a fixed service station, should be of sufficient capacity to serve the needs of all plants being served by each mobile tank unit. In such a case, it must be remembered that any fuel left over should be pumped back into the bulk storage tanks and fresh drawing made for the next day's operation or else, the mobile tank should be filled up completely at the end of the day's work.

11.5. Stores Warehousing.

Store room or warehouse facilities, should as far as possible, be planned to adjoin the section of the maintenance shops which have the greatest need for accessibility to parts. In case of centralised maintenance shops and the centralised stores, at least the two premises should be contiguous to each other if possible, or not too far away from each other.

The warehouse itself must be planned to facilitate handling of materials with the least amount of effort. Fast moving items, mainly mobile equipment repair parts, should be stored where they are easily accessible-with the consideration to dispersal with a minimum of travel. Access aisles must be provided for fork-lift trucks, and bin aisles must be of proper width to accommodate 2-wheel or 4-wheel hand trucks, at a minimum of 3 ft.

Receiving areas should be provided separately with sufficient space to accommodate fork-lift unloading of trucks. A recessed truck platform-level ramp, contained within the building, will provide all-weather loading and unloading of trucks and is desirable in spite of floor space it covers. It is also desirable, if possible, to provide railroad access with a box-car—level ramp situated to unload with a fork-lift.

Material storage requirements must allow consideration for both size and weight of materials. Storage capacity must therefore, be determined with great care. Compartmental draw type cabinets should be provided for every small materials, and steel adjustable shelf cases should be planned to accommodate other variety/sizes of materials. Heavy adjustable pallet racks with engineered safety factors for carrying capacity, must be provided for heavy materials.

Other considerations for storage must include special cabinets for gaskets, door-type cabinets for materials, such as bearings, seals, and other items which should remain relatively dust or dirt free, and cabinets with locked doors to contain high value security items or precision instruments or items on which the issue is strictly controlled.

Special racks or fixtures must also be provided for cables, ropes, rolls of gasket materials and other commodities which require special handling because of odd shapes, lengths or safety in handling.

Consideration must also be given to storage of acids, lubricants, compressed gas cylinders, bulk or bagged materials, steel, and heavy materials. Generally for safety reasons, or because of their bulk, these items cannot be stored in the warehouse proper and will require outside storage or storage in buildings suited to the material. In respect of lubricants specially, and also for other fluid materials, some of which cannot stand variation in temperatures, suitable buildings or cover should be provided for storage. However, in providing for such storage, provision should be made for access either by rail with box cars level ramp or docks which will permit fork-lift unloading and a crane facility to provide for unloading heavy materials from rail cars or trucks.

Storage of tyres needs meticulous care. One of the most important factor governing the life of tyres is proper storage. Tyres are not recommended to be stored outdoors. They are to be stored in a cool, dry and dark shed, In addition to adequate storage facilities, emphasis should be laid on a proper cataloguing system. A placing or commodity numbering system must be provided that will lend itself ready to easy determination and ability to find materials. This system must be determined with the knowledge that warehouse men generally are brought up from the ranks, have average intelligence, but often do not have an accounting background. The present day cataloguing aids should be availed of.

Storage space for spare parts

It is generally difficult to give a scale of provision of storage space and facilities for a defined size of inventory of spare parts. The provisions would vary substantially, according to type and nature of the parts in stock (whether heavy or light, requiring special preservation and maintenance process or special storage arrangements) and quantities thereof. Considering the items of spare parts generally required for maintenance, repair and overhaul of major items of earthmoving machines, certain guidelines could however, be furnished to determine the scale of provision of floor space in a warehouse storing such parts. Guide lines in this respect is given in Appendix 11.2.

11.6 Observations of the Committee on Visits to sites of Work of Different Users of the Equipment.

(a) *Workshops.*

While there is no doubt that most of the project authorities attempt to plan meticulously the layout of the workshops and stores on any operation involving intensive use of equipment, most often such planning does not include detailed consideration of the large number of diversified factors necessary for the purpose and as referred to in the preceding portion of this Chapter. The functional aspects are no doubt taken care of to a large extent; but there again, the sequence of operations functionally involved, in processing equipment for repair and overhaul or in storage of items in the stores, are not considered minutely. The handling facilities and the location of facilities for repair and overhaul result in fairly high amount of expenditure on handling.

Lack of drainage facilities, disposal of waste material and absence of general cleanliness, make the work in the shops rather unscientific and most unhygienic. The floor area inside the shops is not clean and in some cases, there is hardly a proper floor surface. The roads inside the workshop premises are not blacktopped and these cause a serious handicap to the movement of machines specially during the rainy season. Moreover, unhygienic conditions result from such roads. It is a false economy to save a little amount of initial expenditure in providing suitably covered floors inside the shops or in providing blacktopped or pucca roads. Well planned, well designed shops are no more expensive than poor ones.

The Committee have witnessed workshops and stores where either too little space is provided for the amount of work to be done, or too much vacant space is available resulting in unnecessary expenditure on covered space besides the long distances the jobs are to travel from one shop to another for different operations.

Due amount of care and attention is not paid to the convenience of the workers inside the shops. Most often, the workers squat on the floor to attend to repair work, or for doing other miscellaneous works in the shops. The basic requirement, of work benches with vices, is not taken care of to the required extent. It is needless to point out that lot of time can be saved in doing a given ite mof work in the shops if such facilities are provided for the convenience of the workers and the work.

Absence of compressed air lines, handicaps cleanliness of parts used in reassembly/or overhaul of machines. This also precludes the use of pneumatic tools which make the principal time saving appliance for jobs like removing or tightening bolts, nuts and screws.

(b) *Ware-houses.*

In respect of warehouses, it has been observed that not much care is bestowed upon the conservation and preservation of items in storage—specially spare parts. The parts are stored in shelves which extend in height over 10 to 12 ft. This makes it difficult for dusting of the parts at regular intervals. No care is taken of important items like bearings, seals and gaskets. The gaskets specially get crumpled due to long storage and exposed to open conditions, while these are not mounted on proper

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frames with dowel pins holding them. Similarly, the bearings are also left exposed, without their being wrapped in oil paper after these have received a quoting of anticorrosion lubricant. Initial deterioration in the physical condition of such items, shortens the life of these components when put to use.

Items like crank shafts, which are very expensive otherwise, are also left rather cared for inadequately or improperly both in regard to its preservation and type of storage. The crank shafts are generally observed to be lying flat on the floor instead of being put vertically or supported with fixtures to prevent even slight bending while in storage for long time, due to its dead weight. The crank pins and journals are not covered suitably with a preservant and oil paper.

In the matter of dispensation of lubricants in the shops, a lot of contamination is allowed to be introduced by manual handling. The measures used are most often made out of G.P. sheets with the neck portion of such containers being not wide enough for accessibility to the bottom of the containers for proper cleaning. It is not a rare occurrence to find deposit of grit and dirt at the spout of the containers and at its bottom. Naturally, lubricants dispensed in this manner with such containers would accelerate the pace of wear and tear of the mechanical parts inside a machine receiving lubricants through such containers.

The Committee have considered it necessary to give a broad outline of provisions to be made in the project estimates towards cost of shops to be provided, the equipment to be installed therein and the number of persons to be employed relative to the size of fleet of equipment in operation. Even though these are barely guiding figures, it is considered that it would be helpful for an average user of equipment to clearly envisage the likely requirement of funds for such maintenance facilities to be provided. Following are the brief details in this respect:—

1. *Workshop floor space*

(a) Covered space :

(i) Main repair shop .	150 to 180 sq ft. per machine.
(ii) Field repair shop .	100 to 120 sq. ft per machine.

(b) Uncovered space :

Main repair shop .	two and half to three times of (a) (i)above.]
Field repair shop .	Same as (a) (ii) above.

(c) Cost of covered and uncovered space and sheds :

1.5 to 2% of the cost of equipment.

2. *Requirement of skilled and unskilled labour :*

(a) Planned maintenance	1.5 skilled men per machine and 10% extra for unskilled labour.
(b) Emergency maintenance	10% of (a) above.
Supervisory personnel.	10% of the skilled personnel at (a)&(b) above.

3. *Requirement of shop equipment & Tools.*

4 to 6% of the cost of equipment.

11.7. Summary of Observations and Recommendations.

For any work involving intensive mechanisation, a good workshop is the best asset as it provides the supporting life-line for continued and sustained operation of the plant and equipment. Its usefulness, however, can be as effective as the initial planning recording its layout and established facilities could make it. If the purpose for which the workshops are to be established is clearly defined in specific terms in relation to the items/types of work to be done, the purpose would be well served. These considerations are however, only partially covered while planning the work as a whole. In framing project reports, details of the work load for the shops is not precisely defined; and consequently, provision for space, type of building the equipment and facilities to be installed therein and sometimes even the location of the shops, are not clearly demarcated. This results in inadequate provisions to meet the actual load of work when it is in full swing. One of the basic principles in workshop planning—room for expansion, makes the main deficiency in initial planning. Opposed to this, in some cases, provisions are excessive and dis-proportionate to the likely workload that may be expected even in the peak periods of work.

Some times, the type of construction, the lay out of the service roads and parking spaces, drainage facilities etc., are not properly decided upon in spite of the climatic and geographical conditions being known this becomes a great handicap to work later on.

The imbalance in the equipment and facilities and the size of the shops, as provided and otherwise actually required, has resulted from the pattern of maintenance and repair work not being clearly decided upon initially.

The lay out of the shops most often does not provide for so organising the repair work that specialisation could be attained and concurrent processing of repairs to assemblies, sub-assemblies and components of a machine, could be carried out for overall reduction in the total repair time of a given machine.

Hygienic conditions do not prevail within the workshop premises and the work areas.

Lack of proper tools and inadequate facilities for handling, congested work spaces in different shops, lack of provision of fitters' benches and other such facilities, handicap the progress in work. All this is a result of lack of proper planning and inadequate provision initially made on this account in the original estimates.

The type of construction for stores and warehouses, the equipment and facilities provided therein have sometimes proved problematic. Providing C.G.I. sheet covered sheds of the type of Nissen Huts for storing costly items of spare parts for earthmoving machines, in places where the day temperatures in summer touch 45°C to 47°C is not a rare phenomenon. Physical deterioration of certain items like filters, gaskets, rubber components and seals etc., result in substantial losses of such parts, in long storage under these conditions, makes these items unusable in course of time.

The type of storage bins provided at some places do not provide for safety against hazards of fire, etc.

The method of storage of certain items like gaskets, tyres and tubes, rubber materials, insulation materials etc., is not proper and often renders a part of these items unserviceable before these are used.

Recommendations.

1. Initial planning of workshops at the stage of formulation of project reports should cover all details regarding items and types of work to be done, the maximum work load possible to arise in respect of each, the pattern of maintenance and repair of equipment—whether centralised or on area maintenance basis, or a combination of both, the type and the extent to which work will be got done by outside agencies, and the amount of investment that can be made.

2. A clear plan should be developed of the lay out of the shops by listing out the type of of repair work, manufacturing servicing and maintenance operations to be assigned to the shops commensurate with the number and type of machines, plant and equipment to be maintained and serviced, and the load of manufacturing activities. Further room for expansion and flexibility of operation inside the shops should be provided for.

3. The type and sizes of the workshop buildings should be decided upon with due consideration to climatic conditions, geographical location etc. Clear provision should be made for drainage facilities, parking spaces, storage of raw materials, equipment awaiting work in the shops, repaired equipment awaiting delivery to the users etc.

4. Properly laid service roads and stabilised shop floors, to suit the type and size of equipment that will move over it, should be provided.

5. The location of the shops should be decided upon by preparing a clear plan of the operational activities which will be served thereby.

6. Size of each shop should be determined by the number of workmen that will have to work there and the type of equipment, components, assemblies, that will be put to repairs. Provision should also be made for storage of the components, parts and assemblies and for the fitters'/workmen benches. There should be no congestion of the work-space.

7. Adequate material handling facilities should be provided, both inside the shops and in the open space outside.

8. Adequate provision should be made in the project estimates to meet the cost of workshop buildings, equipment and facilities, in accordance with the guide lines mentioned in the report.

9. The work in the main repair shops should be sub-divided according to the functional requirements so as to accomplish concurrent repairs of components and assemblies for expeditious completion of the repair of any given machine.

10. Where major repairs are to be carried out at the site of the work, functionally designed mobile repair shops mounted on trucks and equipped with full complement of tools etc., should be provided.

11. The area maintenance shops should be located as near as possible to the scene of operation, and good access roads also provided.

12. Store room and warehouse facilities should be located adjoining the maintenance shops.

13. Receiving areas in the ware houses should be provided separately with sufficient space to accommodate mechanical handling of loading and unloading operations.

14. Special attention should be paid to provide a proper construction of the building for storage of tyres and tubes. A cool, dry and dark shed is required for this purpose.

15. A proper catalogueing system should be provided so as to facilitate easy determination of the required materials.

16. Out-door storage is an economical answer to growing space demands. Slow moving parts and certain parts/components upon which weather has no adverse effect, can be conveniently stored in the roofless warehouses.

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CHAPTER 12

ORGANIZATION AND FUNCTIONING OF CENTRAL MECHANICAL UNITS IN IRRIGATION AND POWER SECTOR AND SIMILAR OTHER ESTABLISHMENTS IN OTHER SECTORS.

12.1. Establishment of Central Mechanical Units in Irrigation and Power Sector.

12.1.1. *Consideration in the Irrigation and Power Seminar.*

In September, 1960, during the Seventh Irrigation and Power Seminar held at Bangalore, it was considered that even though some major projects have considerable equipment, most of the items are widely dispersed over the different medium and small projects undertaken by the States. Further more, the major projects, where there is concentration of equipment, the functions of operation and maintenance of machinery and keeping up-to-date information regarding performance, utilisation and efficiency, nature and cost of repairs, consumption of oils, spares, etc. are centralised; thus making it possible to have a unitary control on different aspects of works incidental to operation, etc. of equipment. However, in contrast to the conditions existing on major projects the medium and small projects are handicapped considerably in attaining the required degree of efficiency in utilising equipment. The work on such projects being of much shorter duration, it is difficult to organise workshop facilities, sizeable stocks of spare parts, etc., which are basically necessary to promote better utilisation of equipment.

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It was accordingly considered that for proper management of construction plant and equipment working on medium and small projects in different States it would be advantageous to have such resources pooled and controlled by a Central Organisation with a view to obtaining a higher standard of efficiency and better utilisation of the equipment at the disposal of the State Government.

12.1.2 *Functions as Envisaged*

It was accordingly resolved during that Seminar that the State Government may consider the desirability of setting up of Central Mechanical Agencies who would perform the following functions:—

- (i) Planning the requirements of construction plant and machinery for all projects;
- (ii) Procurement of machinery:
  - (a) by new purchase, and
  - (b) from surpluses available on other projects;
- (iii) Laying down proper schedules for census of machinery, history sheets, log books, preventive maintenance, stock account of spare parts etc.;
- (iv) General supervision of operation and maintenance of machinery;
- (v) Planning of major repairs and reconditioning of used equipment;
- (vi) Preparation of lists of spare parts required and procurement thereof;
- (vii) Transfer of machinery from one project to the other within the State, by internal arrangement;
- (viii) Co-ordination with major projects in the State for which Control Boards have been set up, in the matter of maintaining up-to-date records for the machinery including performance data etc.;
- (ix) Co-ordination with the P&M Directorate of the Central Water and Power Commission for disposal of equipment declared surplus by the State Government and in regard to other matters concerning Plant and Machinery;

(x) Recruitment and training of operating and maintenance staff; and

(xi) Review of efficiency and performance of machines and cost accounting of major items.

12.1.3. *Decision for Establishment and Follow-up Action*

The Co-ordination Board of Ministers in taking a view on the final conclusions arrived at during the 7th Irrigation and Power Seminar, accepted the need for establishing a Central Mechanical Unit in each State with the functions as above. The Chairman of the Board asked the Members (Ministers of I&P of all States) to take immediate steps to implement this decision.

In pursuance of this decision, the Central Water and Power Commission and the Ministry of Irrigation and Power have, in the past 10 years, taken follow-up action in moving the Irrigation and Power Departments in all States in the country for establishing the Central Mechanical Units.

12.1.4. *Need for Implementation of Decision.*

12.1.4.1. *Increase in Population of Equipment.*

The need for implementation of the decision has increased all the more due to the large increase in population of equipment in the irrigation and power sector. The value of equipment in I&P Projects in 1960 was estimated at Rs. 500 million approximately; while during the period 1960-1970 the census now taken by the Committee reveals that the value of construction machinery in use on irrigation and power Projects (in different States and on Central Projects) as in December, 1970 was Rs. 1,400 million approximately. Thus, over a period of 10 years the size of construction machinery holdings in the irrigation and power Sector has increased by Rs. 900 million. However, in so far as utilisation of equipment is concerned the accomplishments leave much to be desired as is evident from the details given in Appendices 2.1 & 2.2.

12.1.4.2. *Rehabilitation of surplus equipment.*

It is also observed that surplus equipment rendered surplus on completion of major projects or medium projects, does not get rehabilitated in proper time on other contemporary works within the State. This is one of the reasons for the over-all utilisation of equipment to be low.

12.1.5. *Recommendations of Committee of Ministers.*

The Committee of Ministers constituted in 1968, to recommend measures for elimination of delays in procurement of construction equipment and spare parts required for Irrigation and Power Projects, in taking a view on the functioning of the Central Mechanical Agencies in the States had made the following recommendation:—

"All States in the country should take necessary measures to establish fulfledged Central Mechanical Unit Organisation in the Irrigation and Power Sector. This organisation should serve as a co-ordinating agency on behalf of Irrigation and Power Projects in a State and exercise control in the matter of proper utilisation of equipment, rehabilitation of sulplus equipment and inventory control of spare parts of such equipment. This work should be given top priority."

In making the recommendations as above the Committee of Ministers had also particularly defined some important items of work to be performed by the Central Mechanical Units in the States. Details in this regard are given in Appendix 12.1.

Considering the huge investments kept idle in surplus equipment, the Committee of Ministers had also suggested that the mechanical organisation in each State in Irrigation and Power Sector should be strengthened and the work pertaining to rehabilitation of surplus equipment and spare parts should be assigned to officer on special duty who would co-ordinate with the Central Water and Power Commission for expeditious arrangement to rehabilitate equipment, etc.

12.2. Assessment of the Present Position

It is unfortunate that in spite of clear consciousness on part of equipment owning authorities in the States of the need for better utilisation of equipment, reduction in investment cost and economy in cost of construction, the required amount of effort has not been put in for establishing a unitary control for management of available equipment in spite of recomendations made in this behalf by high powered bodies.

With a view to making an assessment of the present position regarding creation of the Central Mechanical Organisations in the States, the Committee had issued questionnaire (Appendix 12.2), to ascertain as to how effectively are the central mechanical units in States functioning at present (if these have since been established). The information received from the States, in response to the reference made by the Committee (summarised question-wise) is also given in this Appendix.

12.2.1. *Status of C.M.U. in different States.*

A study of the information received reveals the following:—

1. Central Mechanical Units have been effectively organised by Andhra Pradesh, Gujarat, Kerala, Maharashtra, Mysore and Tamil Nadu States.

2. The functions of Central Mechanical Organisations are being performed by nucleus organisations (Circle/Divisions) created by Bihar, Haryana, Jammu and Kashmir, Madhya Pradesh, Orissa, West Bengal and Uttar Pradesh States, even though fulfledged Central Mechanical Units have not been established by them.

3. Assam, Himachal Pradesh, Punjab and Rajasthan States have not yet established such organisations. The Punjab State had, for sometime in the past, established one Division under an Executive Engineer to perform the functions defined for the Central Mechanical Unit, but this division was closed in 1969.

4. Proposals are under consideration with Haryana, Bihar, Jammu & Kashmir, Madhya Pradesh, Uttar Pradesh, Rajasthan and West Bengal State Governments for establishment of Central Mechanical Organisations in conformity with the recommendations made by the Committee of Ministers.

It is noteworthy that in one case a State were reluctant to organise the Central Mechanical Unit as necessary funds could not be made available for running the organisation. It was once suggested by them that the required funds for running of such an establishment be provided by the Central Government. Perhaps the consequent benefits likely to be entailed by such an organisation were not duly evaluated. It is, however, gratifying to note that they have since framed proposals to establish the Central Mechanical Unit.

12.2.2. *Special reference to Orissa State.*

The Committee also consider it necessary to make a special reference to the position obtaining in the Orissa State with regard to setting up of a Central Mechanical Unit. The envisaged functions to be performed by such a Unit were initially assigned to a Superintending Engineer (Mechanical), Hirakud. However, the functionary control was assigned to a Plant and Machinery Committee constituted by the Government of Orissa in 1961. That Committee is comprised of the following members:—

1. Development Commissioner — Chairman.
2. Secretary, Works (Irrigation & Power Department). — Member.
3. Chief Engineer, Irrigation, Hirakud. — Member.
4. Superintending Engineer, Mechanical Circle, Hirakud. — Member-Secretary.

During the visit of the Committee to Hirakud in January, 1972, the Superintending Engineer, Mechanical Hirakud informed that the said Committee had met on six occasions only during the period 1961-71.

The Orissa Government order, issuing sanction of the constitution of the Plant & Machinery Committee, had stated as follows:—

"The Committee shall go into the method and procedure of distribution of the existing materials and make allotment on demands known up-to-date as well as suggest the procedure for speedy utilisation of the material. It shall also have to make suggestions how tc utilise the materials."

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(The above has been quoted from a paper given by the Superintending Engineer (Mech.), Hirakud).

That Committee was to meet twice in a year. However, only six meetings took place during the period December, 1961 to November, 1967. No meeting took place thereafter.

A brief note regarding the proceedings and recommendations made by the Committee in various meetings, as given by the Superintending Engineer (Mech.), Hirakud is at Appendix '12.3'.

It is evident from the details of the proceedings that the Plant and Machinery Committee are principally concerned with transfer/repair/disposal of surplus equipment rather than the functional control of the Central Mechanical Unit.

The Committee have conveyed their assessment on functioning of the Central Mechanical Unit in Orissa State to the Chief Engineer, Irrigation. There is, however, no indication yet about the corrective action, if any, being taken by the authorities concerned to improve the situation and to make the Central Mechanical Unit function properly. It is our view that a Committee, in any form of its constitution, cannot perform the functions of an equipment organisation.

12.2.3. *Performance of Central Mechanical Unit in Maharashtra State.*

In order to illustrate the pattern of organisation and details of the functions being performed by one of the fulfledged Central Mechanical Units, the case of Central Mechanical Unit in Maharashtra State may be briefly described. Following is the text of a note received from Maharashtra Central Mechanical Unit in this regard:—

"(i) A Central Pool of Machinery has been formed in the State and the same is controlled by the Mechanical Organisation. Every year in the month of June census of the machinery existing on the various projects is taken up and a programme is drawn up for its utilisation on the various projects as per the quantities of earth work to be executed in the working season beginning from October to the end of June of the next year. Simultaneously, lists of machinery which is found to be surplus to the requirement of the various projects are prepared and proposals for the transfer of machines from one project to another where the same are needed are prepared. The programme of utilisation of the machines existing on the various projects and the proposals of transfer of surplus machines from one project to another, are discussed and finalised in a meeting of the concerned Chief Engineers and Superintending Engineers of the various projects, held in the month of July/August each year.

(ii) There is one Centralised Mechanical Stores Division at Dapuri, Poona-12 and three Mechanical Stores Sub Divisions located at Nanded, Akola and Nagpur. In addition on all major projects there are Stores Sub Divisions. The duties of the Centralised Mechanical Stores Division situated at Dapuri are as under:—

(1) Planning and advance procurement of spare parts required for the various types of machinery.

(2) Procurement in bulk quantities of misc. materials required for operation, maintenance and repairs of machinery.

(3) Planning and procurement of steel required for the manufacture of gates.

(4) Procurement of Import licences for spares and materials.

(5) Inventory control of spares and materials stocked in the various Mechanical Stores Sub Divisions in the State.

(6) Disposal of surplus spare parts and materials.

(iii) Additional equipment required to be purchased for the Central Pool of Machinery is decided in the meeting of Chief Engineers and Superintending Engineers held to discuss the matter regarding distribution of machinery, among various projects, in the month of July/August each year and the matter regarding purchase of the same is entrusted to the Superintending Engineer, Mechanical Circle (Construction Plant), Poona. Machinery which is indigenously available is procured either by placing indents against Director General of Supplies and Disposals Rate Contracts or through the Central

सत्यमेव जयते

Stores Purchasing Officer, Bombay. As regards the imported machinery the usual procedure of calling for tenders through advertisements in the Indian Trade Journal and submitting necessary proposals to the Central Water and Power Commission, New Delhi for release of foreign exchange, is followed.

As regards spare parts advance planning for their requirement and procurement is done centrally by the Centralised Mechanical Stores Divisions, Dapuri in consultation with the Superintending Engineer, Mechanical Circle (Construction Plant), Poona. Fast moving spare parts are generally ordered and stored by each Executive Engineer (Mechanical).

(iv) Bin Card recording system for spare parts and materials is followed in the Central Mechanical Stores, Dapuri and in the Mechanical Sub-Division at Nanded, Akola and Nagpur. Ledger system is being followed in the Mechanical Stores Sub-Divisions situated at the various Major-Projects.

The system of Central Inventory Control of spare parts of Heavy Earthmoving Machinery has been introduced and its control is assigned to the Central Mechanical Stores Division, Dapuri. In this regard the Executive Engineer, Mechanical Stores Division, Dapuri, is assisted by the Officer on Special Duty who is also of the rank of Executive Engineer.

(v) So far no equipment has become surplus to the State.

(vi) The State is divided into 3 regions viz.

1. Western Maharashtra.
2. Marathwada.
3. Vidarbha.

In each region there is a Regional Workshop as well as stores. The Regional Workshops are situated at Dapuri, Nanded and Akola. In addition to the Regional Workshops, small Repair Workshops are established at Aurangabad, Latur. Field workshops are also set up at the various Major projects to cater to the needs of the machinery operating on those projects.

It is further proposed to set up small Repair Workshops at Nasik, Satara, Dhulia, Ahmednagar, Bhir and Nagpur.

(vii) The Central Pool of Machinery under the Mechanical Organisation has started functioning with effect from 1-4-1967. It is mainly intended for departmental execution of Major and Medium Irrigation Projects in the State. Earthwork pertaining to almost all the Major Irrigation Projects and many Medium Projects is being executived by the Mechanical Organisation. In addition some Minor Irrigation Works are also being handled by Mechanical Organisation according to necessity.

As already stated above the Central Pool of Machinery is operated under the Mechanical Organisation.

The quantities of earth work executed by the Mechanical Organisation since the year 1966-67 to the year 1967-71 are given below:—

Year	*Quantity of earthwork*
1966-67 . . .	236.78 Mcft.
1967-68 . . .	222.00 Mcft.
1968-69 . . .	243.65 Mcft.
1969-70 . . .	271.98 Mcft.
1970-71 . . .	276.57 Mcft.

(viii) The work of Plant planning for the various Major, Medium and Minor Irrigation Projects is being done by the Mechanical Organisation in the State. The matter regarding purchase of equipment for the Central Pool of Machinery as well as for various Minor Irrigation Projects, is finalised in the meeting of Chief Engineers and Superintending Engineers concerned with the various projects. The purchase of machinery is done Centrally by the Mechanical Organisation only.

The value of the machinery purchased by the Central Pool of Machinery from the year 1967-68 to 1970-71 is as under:—

(The Central Pool of Machinery is formed in the year 1967 only).

Sr. No.	*Year*	*Cost of machinery purchased* Rs.
1.	1967-68	3,90,75,000
2.	1968-69	2,74,09,000
3.	1969-70	2,57,38,000
4.	1970-71	2,07,19,000

In addition to the work of operating, maintaining and repairing the Central Pool machinery, the Mechanical Organisation also carried out the work of inspection of unserviceable machinery belonging to the I&P, B&C and P&H Deptt. of the Government of Maharashtra and of the Zilla Parishads, and of issuing requisite certificates regarding the machinery being unserviceable."

The evidence of efficient management of equipment operation on Irrigation and Power Projects in Maharashtra State is found in the consistency in figures of annual production (earth work done) as indicated in point (vii) above. The quantity of earth work executed during the period 1966-67 to 1970-71 varies from 236.78 Mcft. to 276.57 Mcft., the average figure of annual production being 250 Mcft. approximately.

It is also noteworthy that equipment worth Rs. 113 million approximately has been added during the period 1967-68 to 1970-71; & planning in this respect has been done by the Central Mechanical Organisation only. The total value of equipment in use in the Irrigation and Power Projects is of the order of Rs. 140 million. No serious complaints about difficulties in repair and overhaul of equipment have been made by the Maharshtra State in the past few years, though as a result of procedures and policies under the import trade control regulations, some handicaps have been generally faced in the matter of procurement of imported spare parts. This however, is a difficulty faced by most of the users of such equipment in the country.

The Central Workshops under the Central Mechanical Organisation, Maharashtra State, also manufacture gates and other structural items required for the Irrigation and Power Projects. Spare parts which are not readily available from the market and which are specially required for commissioning of some of the machines, are also manufactured by them.

Regional Workshops operating under the Central Mechanical Organisation are located at Dapuri, Nanded and Akola. These regional shops cater to the needs of the projects falling within the respective regions and serve as a nucleus for repair and over-haul of equipment and components, and for storage of costly items of spare parts. The fast moving items of spare parts are, however, stocked by the individual users of equipment near the respective worksites.

The Organisation has 3 Superintending Engineers (Mechanical), for operation and maintenance of construction plant and equipment including one for manufacture and erection of Radial Gates, Sluice Gates, Hoists, etc. and for carrying out fabrication work of other structures that may be required.

Occasionally, the Central Mechanical Organisation undertakes structural work and equipment repair work on behalf of other State Government Departments also. Thus, the Organisation has a State-wide utility in the matter of construction plant and equipment and steel fabrication work.

The Maharashtra State have decided to appoint a Chief Engineer (Mechanical) for overall control of the Central Mechanical Organisation in the State.

The Committee feel that there has been considerable delay on the part of the State Governments to implement the decision of the Co-ordination Board of Ministers of Irrigation and Power and the Committee of Ministers, in the matter of setting up Central Mechanical Units even though the utilisation of equipment has not been satisfactory in the Irrigation and Power Projects for a long time. This is a very important subject for prime consideration of the State Authorities and they should not lose any further time in implementing the decisions taken jointly during the I&P Seminar.

12.3 Observations of the Committee

The need for functional co-ordination on the part of the Central Agency in a State in relation to equipment has been fairly elaborated in Chapter 6. The main benefits in view are: reduction in inventory of spare parts, reduction in capital investment in equipment, optimum utilisation of equipment and maximum productivity from the machines available in a State. Sometimes the State Authorities are not fully aware of the losses that are accruing in consequence of idle time depreciation of equipment, the recurring expenditure by way of inventory holding costs on items of surplus spare parts, additional investments made by them in purchase of new items of equipment and spare parts for new schemes even when some surplus items of equipments and spare parts can be made use of.

12.3.1 *Functional Activities—Economic Aspect.*

In order to highlight the functional importance of the envisaged activities to be assigned to the Central Mechanical Units, the Committee have considered it necessary to specify the economic aspects which may make direct attributes of the defined functions:—

1. Making the initial selection of equipment of considerations of economy in end-cost of product. This would involve planning the requirements of equipment by categories, combinations of the items in different categories and quantities to give production according to pre-determined targets as defined by the phased programme of work.

2. Finalising procurements of machinery only after taking into account the required items that will be available as surplus on other projects in the State, thus reducing the amount of additional investment on this account in the State as a whole.

3. Enforcing 'Standard Practice Instructions' for proper supervision of operation and maintenance of machinery thereby reducing breakdowns and overall maintenance and repair costs.

4. Enforcing proper measures for inspection and preventive maintenance with a view to conserving the worn out parts, thereby reducing the expenditure on replacement parts, extending the life of the equipment and parts and arranging to repair and overhaul the equipment methodically, thus reducing the expenditure on this account also.

5. Enforcing proper inventory control methods for spare parts, thereby reducing the stocks of parts, ensuring ready availability of the required parts and reducing to the minimum the quantities in respect of slow moving items of spare parts that generally make the dead-stock on completion of work on a project.

6. Minimising the idle period of surplus equipment by timely rehabilitation on new jobs, thereby making the investment fully productive and reducing the idle time depreciation charged to the work.

7. Recording properly the results of performance of equipment, the costs of maintenance and repair etc. with a view to determining clearly the areas in which improvements can be made for overall reduction in owning and operating costs of the equipment. Such record would enable future estimates of costs of work to be properly framed, where similar equipment may be used. This would also help in establishing norms and standards etc., for performance, availability, utilisation and productivity of given items of machines.

8. Facilitating training of operating and maintenance staff, so as to introduce better efficiency in overall operation and utilisation of equipment for maximum productivity and lesser maintenance cost.

9. To undertake mechanised construction work involving use of heavy earthmoving machines and other construction equipment on medium and minor Irrigation Projects in the State.

Before any mechanised construction work is let out to contractors, refusal of the Central Mechanical Unit should be obtained by the respective Departments in this respect in the first instance. It will be helpful if planning for allotment of work to Central Mechanical Unit is done on annual basis before the beginning of the financial year or the working season, so that timely completion of envisaged work can be assured on the one hand and sustained use of equipment available with the Central Mechanical Unit made certain on the other hand.

The above aspects are a direct interpretation of the individual functions as laid down for assignment to the Central Mechanical Units.

12.3.2. *Function of Central Mechanical Unit in relation to work with equipment in major Projects.*

The relative functions of the Central Mechanical Unit vis-a-vis Major Irrigation/Power Projects in the State would be as follows:—

12.3.2.1. *Plant planning.*

The Head of the Central Mechanical Unit should be an active Member of the Committee finalising plant planning for a given Major Project. If there is no such Committee the association of the Central Mechanical Unit Head with the plant planning exercise may be stipulated. By this process it would be possible to determine:

(a) how much equipment can be diverted from other projects in the State where the same may be available for rehabilitation;

(b) to properly fit in such available equipment into total work system for plant and equipment as being planned for the project;

(c) basing the plant planning exercise on practical norms and standards of productivity, cost of maintenance and repairs, consumption of materials and spares etc. etc. and

(d) standardisation.

12.3.2.2. *Standard practice instructions regarding maintenance, repairs of equipment*

The Central Mechanical Unit will furnish a ready compilation in this respect for adoption by the project authorities so that all record keeping and the drill to be followed in relation to operation, maintenance etc. of equipment can be done according to standard practices.

The Central Mechanical Unit will povide the project with basic records relating to consumption pattern of high value items of spare parts, POL item and other materials for specified items of equipment that may be proposed to be selected for use at the project.

12.3.2.3. *Indigenous manufacture of spare parts*

If the Central Mechanical Unit has organised facilities for indigenous manufacture of some items of spare parts, and it has the available capacity for undertaking manufacture of additional items at the request of the project, detailed listing of parts that can be so produced can be done so that the project can avail of the facilities of the Central Mechanical Unit in this respect for ready supply of some of the parts.

12.3.2.4 *Surplus equipment*

As and when any item of equipment gets surplus on the project, the Central Mechanical Unit would take over these items and arrange to get them rehabilitated on other projects in the State or outside, so that the equipment does not remain idle. Though normally equipment gets surplus when the work on the project is completed, there are certain special items of equipment which may be required on the Project for a short periods only. By this the reference is to equipment used for construction of diversion tunnels—mucking machines, pumpcretes, etc.

12.3.2.5 *Repair facilities*

In emergent situations, when there is a sudden on-rush of repair work relating to equipment, the project authorities feel handicapped in carrying out the repair works to the machines in specified periods of time. In such cases they can draw upon the resources of the Central Mechanical Unit in the matter of manpower and repair facilities for expeditious repair of equipment.

Sometimes ready, reconditioned, serviceable assemblies/sub-assemblies and components can be provided by the Central Mechanical Unit for particular machines so that the repair work on the project is expedited. This would be more true of projects costing Rs. 10 to 15 crores, where extensive workshop facilities cannot be created due to inadequacy of funds for this purpose or due to inadvisability of such investment on short-term basis.

12.3.2.6 *Advisory role*

The officer-in-charge of Central Mechanical Unit can serve as an independent inspection authority for the construction equipment used on a major project. His observations, suggestions and recommendations on certain technical points, which may normally be over-looked by the projcet staff in the routine of activities on the job, may help in corrective action being taken in time for preventive maintenance of equipment.

12.3.2.7 *Creating a central record for the performance of equipment*

The Central Mechanical Unit can organise time and method studies, analysis techniques etc. to creat a clear record of performance of equipment—technically and cost-wise, and simultaneously suggest introduction of improvements in certain methods for increase in productivity and reduction in cost.

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The Central Mechanical Unit can also serve as the propagation medium for distinct items of information relating to technical performance and cost data in respect of equipment working on different projects in the State so that, project authorities can benefit from such information and analyse their operations for entailing economy and for increasing productivity of the machines.

12.3.2.8 *Finalising rate-contracts or prices with suppliers.*

In addition to the functions of scaling the consumption of materials and spare parts etc. the Central Mechanical Unit can create a master record of notable suppliers of these items relative to the equipment on use on a major project. Further more it can finalise prices in respect of such items on competitive basis. This will save the project authorities sometime in processing their requisitions for procurement to the point of purchase orders being placed.

12.3.2.9 *Interchangeability of parts/assemblies/components.*

Since the Central Mechanical Unit would also be compiling necessary records in respect of interchangeability of assemblies, sub-assemblies, components and parts relating to different makes and models of machines in various categories, such information can be availed of by the project authorities in controlling the stock of spare parts, simultaneously acquiring the know-how regarding selection of items from the stocks for ready repairs to machines, when such parts may not be available for a particular make and category of the machine.

12.3.3 *Guidelines for Establishment of Central Mechanical Units.*

The Central Water & Power Commission have in the past issued necessary guidelines for establishing Central Mechanical Organisations in the States in the Irrigation and Power Sector. These guidelines cover the basic steps to be taken prior to setting up of the Organisation, recommended set up for workshops, planning for shops and stores, creation of inspection organisation, training of personnel etc. etc. The benefits that may accrue from a well-established Central Mechanical Organisation were also clearly defined therein. A brief resume of the guidelines as published, are given at Appendix

12.4. As a further addition to what has been indicated in that Appendix, the following may be stated:—

1. The Regional Shops and Stores should organise arrangement supply of components and sub-assemblies to the users of equipment in the region. They should additionally provide for repair and overhaul of the sub-assemblies and components removed from the machines for repairs. They should carry necessary stocks of spare parts for reconditioning of the unserviceable assemblies and components.

2. For convenience of transport of the reconditioned sub-assemblies and components to work-sites suitable transport arrangements should be available ready at hand. The efficiency of the system would result from the expedition in carriage, to and fro, of the reconditioned items to the work-sites and of the replaced unserviceable items back to the shops.

Standarised packing cases should be readily available-premanufactured, so that the reconditioned items can be carried over without being damaged and the unserviceable items also brought back without any further physical damage during transit.

3. The re-building of worn out components e.g. the under-carriage components on Crawler Tractors, should be done in the Central Workshops. The Central Workshops should provide spare reconditioned or re-built under-carriage components and distribute the same in the Regional Workshops/Stores, for ready supply to the users of equipment in the field in different territories or regions.

4. Main stock of standby components and sub-assemblies should be carried by the Central Workshops or the Headquarters of the Central Mechanical Organisation. Further distribution should be regulated according to equipment types/makes/population amongst the Regional Shops/stores.

5. Procurement of spare parts etc. and items of maintenance supplies, should be done by the Central Mechanical Organisation at Headquarters.

12.4 **Conclusions**

In conclusion it can be only stated that for proper management and control of equipment operations with a view to ensuring optimum utilisation, maximum productivity, least downtime, least cost of end-product produced by the machines, it is very necessary that there should be a Central Co-ordinating Agency at the State level for all the construction plant and equipment in use in the State. The direct benefits resulting from initial planning of equipment for all construction works in the State including the most important items of work namely, timely rehabilitation of surplus equipment and ensuring sustained utilisation of equipment on the job, make it necessary that overall functional control of the Organisation should be assigned to a Manager having professional skill and specilisation to the required degree and entrusting him with proper authority commensurate with the responsibility of the duties assigned. Even though the work of operation, maintenance and utilisation of equipment working on Major Projects is generally outside the purview of the Central Mechanical Organisation, maintenance supplies and spare parts, which put together account for 200 to 300% of the cost of equipment over its lifetime, have to be arranged by the Officer-in-Charge of the Central Mechnical Organisation. Moreover it has to be his function to introduce standard practices for proper operation, maintenance and repair of the equipment at all project works in the State. The functions as such make his position the pivotal point on which the economy in operation of equipment hinges. It is, therefore, essential that he should be of a proper status.

Considering the amount of equipment working in individual States as at present (barring a few), the officers manning the Central Mechanical Organisations in 'Major States' should be of the rank of 'Chief Engineer'. Organisational chart showing the functional distribution of work is given in Appendix 12.5.

12.5 Co-ordination—Activities in other Major Sectors.

The other Major Sectors where large scale mechanised operations are involved and intensive use of heavy earth moving machines is made, are the Iron-ore Mining Sector, Coal Mining Sector, Lignite Mining, Land Reclamation and Road Construction Sector. The spread of work is very wide in the land reclamation and road construction Sector while in the Iron-ore, Coal and Lignite Mining the concentrated type of work on individual mines makes each project a self-contained unit.

12.5.1 *Mining Sector*

Overall control and co-ordination in relation to the mining sector is done through an agency at the Headquarters in the spheres of planning, production, engineering, finance and materials management. However, the equipment in use having generally to expend its entire span of economic life on a specific job at a single given location, the nature of problems as en-countered on Irrigation and Power Projects is not found on these works. Centralised control on procurement of equipment, inventory control of spare parts, arrangements for supply of maintenance material etc. is done in the same manner as has been defined in relation to the functions of the Central Mechanical Organisation in I &P Sector. These projects being in areas, where the pattern of accounting and operations is on commercial lines, it may not be necessary to make any more suggestions. The only suggestion for improvement that could be made is in the field of disposal of surplus equipment—equipment which has been retired from the job at the end of its economic life. If the disposal of such equipment is centralised at one location or under one authority in the sector, it may be possible to finalise action in this regard more expeditiously. If each individual project in the Mining Sector has to initiate action separately for disposal of the surplus equipment the net advantage to the State or to the Organisation may be comparatively, smaller.

Co-ordination in dissemination of important data relative for performance of equipment has also to be done by the Headquarters office. Master record of information History sheets, production statistics, Time and Methods study results, operation research, consumption record in respect of high value items, etc. etc., has therefore also to be maintained at Headquarters. Periodical meetings amongst all equipment managers under an Organisation like N.M.D.C., N.C.D.C. should be organised when important aspects of work relating to equipment can be fully discussed and decisions taken for introduction of methods of improvement etc.

12.5.2 *Ministry of Transport*

The Directorate General of Roads in the Union Ministry of Transport, have still a different pattern of management of equipment from the stand point of co-ordination with the States/the users of the equipment in the field. The ownership of the equipment lies with the Union Ministry of Transport and they take all necessary action for initial procurement of the equipment and spare parts etc. However, after acquisition the machines are transferred to the State Public Works Departments concerned. Once the equipment is delivered to the State Departments the responsibility for its operation, maintenance and utilisation is entirely theirs. Collection of performance data or maintenance of other records relating to operation, repairs and overhaul etc. of equipment is also the responsibility of the State Departments. The equipment owning authority has hardly any control on the overall utilisation of equipment.

If the management control and co-ordination has to be effective in a proper manner, it is only essential that feeding back of information regarding performance, utilisation, etc. of equipment is done by the respective State Department to the Ministry of Transport. The Ministry of Transport can then draw up clear plans for re-apportioning of the available equipment to different works in different States from time to time, with a view to sustaining the entire fleet of available equipment for proper utilisation on the job, whenever the work on which these are employed gets completed.

The Ministry of Transport have now considered the practical problems they are faced with in this matter—specially those relating to poor utilisation of equipment and have decided as follows:—

"The ownership of the sophisticated and costly equipment will lie with the Ministry of Transport themselves and the rest of the equipment which are not very costly will be owned and operated by the State Public Works Departments. The consideration behind this decision was that since there would be only a few items of such sophisticated and costly equipment required for road building purposes, managing the operation and maintenance of these few pieces of equipment by the Ministry themselves, would not be difficult task."

12.5.3 *Rehabilitation & Reclamation Organisation*

In so far as the Land Reclamation Department is concerned (in the Ministry of Labour, Employment and Rehabilitation), even though there are over 13 field machinery units in this Organisation each unit is self-sufficient in the matter of facilities for maintenace, repair and overhaul of machines. This is necessary because field machinery units are working at places which are very far apart from each other. Some units are working in the Andaman Islands, while others are in other remote places in the country. All the same, in so far as procurement of equipment and spare parts or the record relating to operation, repairs, maintenance, etc. is concerned, the central agency at one location (in this case at Jeypore in Orissa) controls it. The working of this organisation has been fairly successful under these arrangements even though occasionally some of the units had faced difficulties in having sufficient work to keep the machines busy.

12.5.4 *Interdepartmental Coordination*

The aspects of Inter-departmental Coordination and Intra-departmental Coordination in matters relating to construction plant and equipment have been elaborately dealt with. The Central Mechanical Unit would be the agency in the State for such co-ordination activities in relation to projects and departments within the State. In addition, the Control Mechanical Unit would also establish co-ordination with the Central Mechanical Units in other States through the Central Water and Power Commission's Coordination Cell, and the Liaison Unit Division under it.

The Coordination Cells in various other sectors using such equipment would also similarly co-ordinate with the Central Water and Power Commission in the matter of exchange of information relating to plant and equipment.

12.6 **Summary of Observations and Recommendations**

Even though a decision was taken in September 1960, during the 7th Irrigation and Power Seminar held at Bangalore, to set up a Central Mechanical Unit in the Irrigation and Power Sector in each State, so far only six States have implemented this decision by setting up fulfledged central mechanical units. Another seven

States, in recognition of the need for setting up such units, have created nucleus organisations for performing the functions that were to be assigned to such units. The remaining five main States have not yet set up any such agency.

The Central Mechanical Units are effectively functioning in Andhra Pradesh, Gujarat and Maharashtra States only.

Coordination activities in other major sectors e.g., mining sector, road building and land reclamation, have been organised at the respective headquarters of each Department/Undertaking controlling the projects/works under their charge.

The main objective in creating such coordinating agencies was to pool the resources by way of equipment, parts, facilities, and personnel within a sector/State, so that higher standard of efficiency and better utilisation of equipment could be achieved. The direct benefits resulting from such coordination were to be found in optimum utilisation, maximum productivity, least downtime etc., of equipment and the least cost of end product produced by the machine. To achieve this in practice, however, it requires a continuous and progressive review of cost and performance data of equipment in regard to operation, maintenance and repair. Unfortunately, the record keeping part is not in a perfect state yet, and consequently, cost evaluation, cost effectiveness, defect analysis and work study part of the functions, cannot be effectively performed by these coordinating agencies.

The Committee of Ministers constituted by the Government of India, Ministry of Irrigation and Power, had also emphasised in their report that the Central Mechanical Units should be expeditiously established in the Irrigation and Power Sector in all States. The progress made in this direction is, however, below expectations.

Recommendations

1. In order that the Central Mechanical Units perform the assigned functions in an effective manner, and considering the amount of equipment working in individual States as at present (barring a few), the officers manning the Central Mechanical Units in the Major States should be of the rank of "Chief Engineer." The functional distribution of work would generally be on the pattern given in Appendix 12.5.

2. In the States where the Central Mechanical Units have not been established or where these are operating as nucleus organisations, should take necessary steps to establish these units at the earliest.

CHAPTER 13

ACCOUNTING FOR THE OWNERSHIP AND OPERATING COST PER PLANT HOUR

13.1 Purpose

For any production work, considerable investment is needed to establish the necessary facilities. The tendency would be to go in for the sophisticated modern machines so that the overall investment results in highest possible productivity. All the same, it has to be recognised that the economy entailed by such production facilities must be sufficient, to absorp the reduction in value of the facilities, as these are consumed in the production process. This "Capital Consumption", as such, forms an important consideration in carrying out exercises for alternative engineering proposals, which could be adopted for accomplishment of given production tasks. Other factors in the consideration of production cost, besides the consumption of capital, are the operation and maintenance costs of machines.

It is thus necessary to develop required data to permit the engineer to estimate as accurately as possible the cost of production for different equipment combinations so as to enable him to decide what set up he would find most economical for a given job. These yardsticks can later be used by him to determine whether a given item of work, on which the machines are employed, is being done economically. It is, however, necessary to qualify that the production costs so worked out would be for comparative purposes only, and for an estimation of the total cost of work. The yardsticks could only be used for an indication, reasonably correct one, of what the ultimate costs of a work might be but one could never expect from these statistically derived figures a guarantee that there would not be departure therefrom.

13.2 System

The equipment costs are generally grouped under two heads; the Ownership Cost and the Operating Cost.

Ownership Cost includes:

1. Depreciation.
2. Interest Charges.
3. Insurance, taxes etc.

Operating Cost includes:

A. Repair expenditure

1. Spare parts
2. Tyres.
3. Repair labour.
4. Workshop charges.

B. Other operating expenditure

1. Operating supplies
2. Operating and maintenance labour
3. Other consumable supplies
4. Supervision and overheads.

In relation to the 'Repair Costs', there are two practices. According to one, the 'Repair Charges' (Cost of spare parts and labour for repair to equipment) are taken under the head 'Ownership Costs' since the repairs are intended to keep the machines in an operating condition as close to the initially purchased condition as possible. The other practice classifies the 'Repair Charges', as a part of the 'Operating Cost', as these arise in the course of operation of the equipment on a given job. The category to which "Repair Charges" belong, however, need not be discussed since the overall rate structure of 'Ownership and Operating Costs' includes the sum total of the above-mentioned items.

13.3 Depreciation

Depreciation cost of equipment is just another word for capital consumption which we have used earlier.

13.3.1 What is to be Depreciated

The cost of an equipment shall be the sum total of the following:—

(1) Acquisition cost including all duties and taxes;

(2) Transport of equipment to site of work;

(3) Erection costs of equipment.

The transport and erection costs under '2' &'3' above are sometimes charged to the work specially when the equipment involved is a special plant e.g. batching and mixing plant, a processing plant, etc., etc. In such cases, since the equipment has to be dismantled and transported for being reinstalled on some different location or on a new job, the cost of transport and erection is distributed over the total quantity of work done by the plant during the period of its working at one location.

On completion of the work, when the plant is to be dismantled and transported to a new location, the cost of transport and dismantling is charged to the new work, to which the plant is taken. If, however, the plant has to be kept in storage for subsequent disposal or rehabilitation on a new work at a later date, even the dismantling charges and transport charges upto the storage warehouse are apportioned to the particular work for which the plant was initially installed.

The dismantling charges are generally taken at 1/3rd of the erection cost for estimation purposes.

In respect of motorised equipment, however, the standard practice is to take the sum total of the items of cost at (1), (2) and (3) above for determining the amount to be depreciated.

The value of the equipment, however, seldom reduces itself to zero, for, even after it has completed its useful life, it can be sold for a certain price. Such residual value should be deducted from the total cost of equipment when considering depreciation (for the lifetime of a machine).

It is a normal practice to account for the depreciation of the cost of the bare equipment without tyres (in the case of the pneumatic wheeled equipment). For the tyres the hourly depreciation is an entirely separate issue.

In case of equipment transferred from another project, the cost to be depreciated will be taken as the total of:

(i) Transfer cost.

(ii) Cost of dismantling at the earlier project.

(iii) Transport charges.

(iv) Cost of re-erection at new project.

(v) Cost of all charges for bringing the equipment to working order.

In case of pneumatic tyred equipment the cost of tyres will be depreciated separately in the manner described later in para 13.6.3.1. of this Chapter.

It may, however, be mentioned in relation to item (v) above, viz., "Cost of all charges for briging the equipment to working condition", that if the equipment is transferred from one Government Department to another Government Department and the transfer cost has been determined on the basis of Declining Balance Method of Depreciation, these charges would not be added to the transfer cost for determining the amount to be depreciated. In case, however, the equipment is purchased from a source outside the Government Departments at a mutually agreed price, the repair charges for bringing the equipment to good working order may be capitalised and included in the figure of amount to be depreciated.

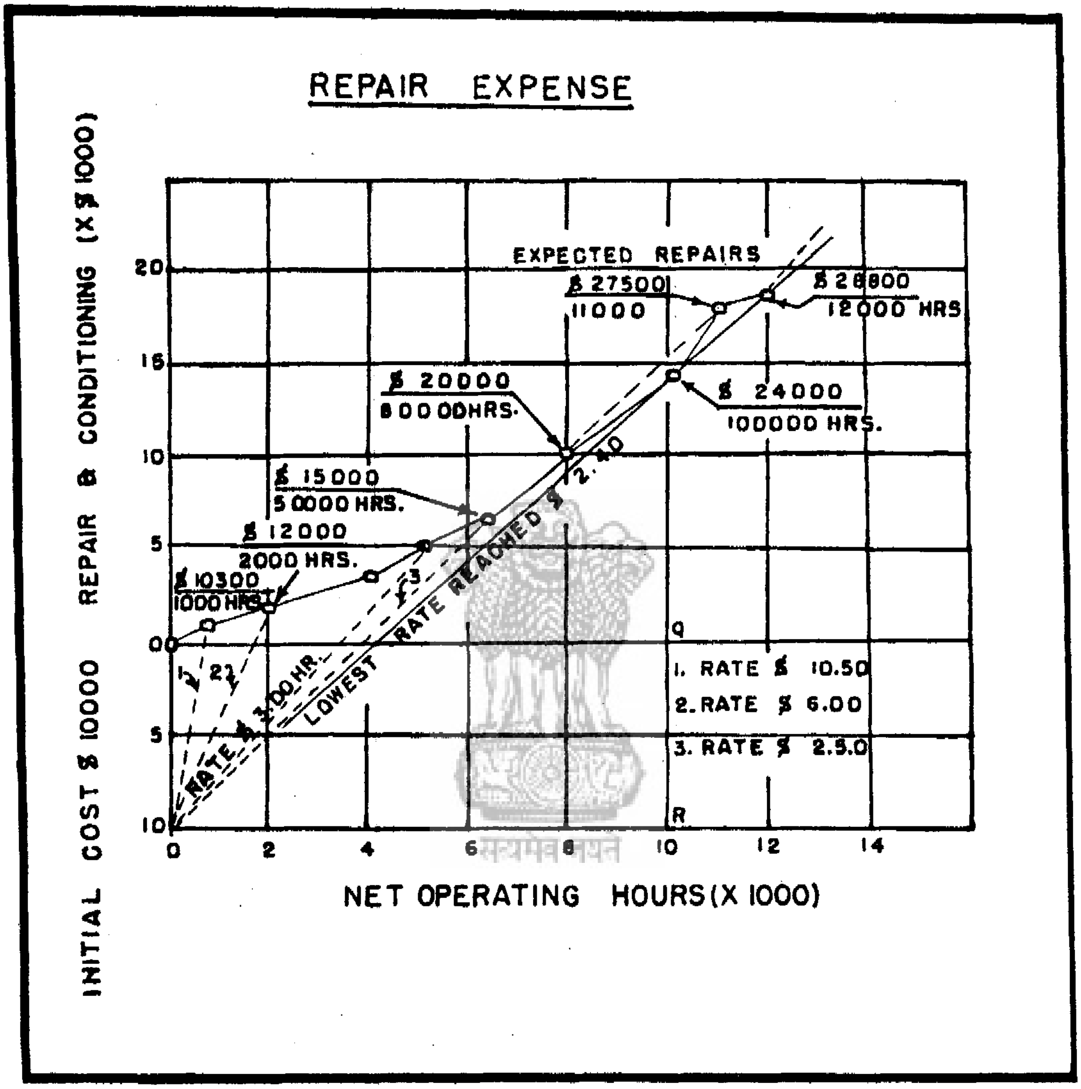
13.3.2 Fixing the Life

To evaluate each one of the above-mentioned elements of cost on hourly basis, in order that accounting for the ownership and operating cost is done on basis of cost per-plant hour, it would be necessary to fix the life of different items of equipment. This subject has been covered in detail in Chapter-8.

The conclusions drawn, based on observation clearly explained in that Chapter, are indicative of the difficulty in defining the figure of life of individual categories of machines in number of hours. This observation is also substantiated by what was stated by the First Construction Plant and Machinery Committee in their report in para 9.1.2., which reads as follows:—

Fixing the life

9.1.2. There is no physical evidence which determines when a machine has reached the end of its efficient life. It can be kept going indefinitely by incurring progressively heavier expenditure on repairs until a point is reached when it will be cheaper to buy a new machine. The optimum life is an economic function, and is reached when the combined hourly cost of "purchase and repairs reaches a minimum. This is explained in the Norris Dam Project from which the following graph is quoted:



Evidently, the considerations in fixing the life of machines are governed principally by the equipment economics and the optimum life is taken as an economic function. The cumulative hourly cost of purchase (Depreciation cost) and repairs, when it is at a minimum figure determines the optimum life of the machine.

In spite of the considerations as above that Committee had made recommendations in Appendix 3.3 of the report regarding figures of plant hours for depreciation in relation to specific items of machines covering ten categories.

In practice, however, in the Irrigation and Power Projects, only some of the project authorities adopted the figures of life so recommended for individual machines under different categories. Neither did any of the equipment users maintain a clear account of the repair costs in order to clearly judge the equipment economics in relation to each machine or a number of machines of the same make and model in a group in a manner as listed in the graph above and consequently precise assessment of optimum life of machines could not be made.

In practice a figure of life is assumed for a given category of machine for purposes of depreciation account. However, if the machine has spent that life on the job and is still found useful, the project authorities revise the figures of life upwards and reckon with depreciation per hour based on revised life figures. In many cases the figures of life adopted by individual projects have been different from those recommended by the Construction Plant and Machinery Committee. The anamolous situation arising out of such reckoning has been explained later in para 13.3.3., but it may suffice to indicate that the Straightline Method of Depreciation, based on discretionary figures of life of equipment as determined by individual equipment owners, has failed to achieve the objective of uniformity in the pattern to be followed in this respect.

In view of the above an attempt has been made by this Committee to rationalise the method of evaluating depreciation.

Before this subject is dealt with in details, a brief mention will be made about the present practices in this respect in the River Valley Projects, the Public Sector Undertakings, and the Private Sector.

13.3.3 Present Practices

The manner in which depreciation costs are calculated is at present varying with different organisations as given below:—

The River Valley Projects are using the straightline method of depreciation, adopting a figure of life of the machines in number of hours, 8,000, 10,000, 12,000 etc., and writing off the cost of the equipment on the job through hourly depreciation rates. A minimum depreciation of 8% is however, charged if the machine does not clock requisite hours. The total amount to be written off, is taken as the capital cost minus the scrap value/salvage value of equipment (this being taken as 10%).

The Public Sector Undertakings generally account for depreciation according to official income tax methods. This provides for fixing the life of a machine in 'Years' and fixing a percentage for depreciation to be charged on the written down value of equipment year after year, or in brief, 'The Declining Balance Method of Depreciation'.

However, a few of the Public Sector Undertakings, namely, Neyveli Lignite Corporation, adopt a 'Straight Line Method of Depreciation' by depreciating the capital cost of equipment equally each year, after accounting for the residual/salvage value of the equipment. In some cases, the total capital cost is divided by the number of years of life of the machine and depreciation charged accordingly at uniform rate each year, except, for the last year, when the amount of depreciation is reduced to the extent of salvage/residual value of the machine.

The Private Sector uses, "The Declining Balance Method" of depreciation, involves fixing the life of equipment in years and accounting for depreciation on fixed percentage basis according to Income Tax Rules and based on written down value of equipment each year.

There are thus principally two methods of depreciation in use in the country:

(i) Straightline method based on life expressed in number of working hours or years;

(ii) Declining balance method based on life expressed in number of years.

The 'Straight Line Method' of course, is the simplest and provides a uniform basis for writing of machine costs. However, the main disadvantage of this system is that it does not provides for a fast write-off commensurate with the physical deterioration of equipment. Compared to this, "The Declining Balance method" provides for a relatively faster rate of depreciation in the earlier years of use of the equipment mainly the first three years and is more realistic of the actual reduction in value of the machine.

The 'Straight Line Method' of depreciation of equipment working in the River Valley Projects, stipulates that the life of the machine be defined in hours. As an example, for the crawler tractors, the life is generally taken as 8000 hours, 10,000 hours, or 12,000 hours, subject to the job conditions being severe/average/normal, or excellent, respectively. However, cases have come to notice where a user in a period of 5 years of operation utilised a machine for the specified life in hours as above and found at this stage that the machine could still be sustained in operation on the job for much longer period, the figures of life were revised upwards, making these 15,000 hrs., 18,000 hours, and even 20,000 hours. The machines then continued to be in use for a period of 8 to 10 years. Another user using the machine for a lesser number of hours each year, could not complete even the basic schedule of life of 10,000 hours under a average conditions over a period of 10 years. The statistics compiled by the Committee, based on returns received from a large number of users, covering a very wide cross section of fields of application indicate that machines purchased over 15 years ago, are still in use and a large number thereof have hardly done 10,000 hrs. Hence, we are to contend with the situation where we have to adopt certain figures of physical life of the machines, as obtained in the country.

There is no doubt, that obsolescence of machines is a very vital factor relating to physical depreciation. Introduction of modern machines with better production capacity and lesser costs in terms of end cost on production, makes the importance of obsolescence more manifest. However, non-availability of such modern equipment and improved models thereof in the country at present, makes us to leave aside the factor of obsolescence outside the purview of depreciation. All the same, realising that obsolescence costs have to be accounted for in some manner, the objetive would be best attained by fixing the life of machines at a figure in number of years, and proper accounting for deprecation at a little faster rate in the earlier years of the age of the machine and following the "Declining Balance Method" of depreciation.

Another method of depreciation followed elsewhere is the sum of the years' digit method. However, this is rarely followed in this country.

13.3.4 Declining Balance Method of Depreciation—Need for Adoption in Relation to Major Items of Construction Equipment

In making the study of present practices in accounting for depreciation annually, the Committee came across instances where inspite of the age machines being 8 to 10 years (since the time of their purchase), the residual value of the machines ranged from 40 to 50% of the initial acquisition cost. The residual value as such was evidently reckoned on the basis of accounting of depreciation by Straight-Line Method commensurate with the hours for which the machines were in operation during that period. Such machines having grown surplus to the requirement of work at projects, could not attract any prospective purchasers for future use mainly due to their physical age and the high figure of residual value. On the other hand, the project authorities who had initially purchased these machines had debited the depreciation to works (on which these were used), only to the extent of numbers of hours of operation. The prospective buyers were mainly guided, in declining to acquire this asset for further use, by the physical age of the machine; and felt that the transfer price which was equivalent to the residual value was out of proportion to the age of the machine.

The first user of the machine did not have any means to accommodate or absorb any further reduction in value of the machine for sale/transfer to a new buyer except by accounting for such reduction below the depreciated value as a loss in revenue. Psychologically there is a geat resistance on part of the equipment owner to show invisible losses without the equipment being in use and for the prospective buyer to show a higher figure of acquisition cost when the machine is fairly aged. Such consideration has most often left the surplus equipment as idle, besides resulting in additional investment by the prospective buyers in acquiring new machines.

Further more, on evaluating the cost per unit of products produced by such equipment, a degree of inconsistency was noticed from year to year. This was mainly due to the fact that the hourly rate of depreciation of equipment being a fixed figure, the actual repair costs of equipment varied from year to year—progressively increasing commensurate with the age of equipment, while the productivity of machines in the initial stages being higher than in the later years of life of the machines, the cost per unit of product produced in the earlier years of the life of the equipment was much lower than what it was to be in the latter part of the life of the machine.

The Committe were, therefore, led to serious thinking as to the method of accounting of depreciation so that such anamolies could be conveniently removed and the available equipment put to use not only to the advantage of the prospective buyers, but also to rationally account for the amount of depreciation to be booked to the particular work for which the machine was initially purchased. The Committe accordingly, reckoned with the possibility of adopting the "Declinig Balance Method of Depreciation" as a uniform procedure by all equipment users in the country in various sectors.

The main features of the "Declining Balance Method" taking into account the intensity of use of equipment, residual value etc., are indicated below.

13.3.4.1 Rate of depreciation and schedule life to vary with intensity of use of equipment

(1) The pattern of daily work is first decided upon—whether the work would be done in one shift, two shifts or three shifts per day.

(2) Corresponding to this pattern, a figure of fixed percentage is decided for annual depreciation. In relation to crawler and wheeled tractors, motorised scrapers, dumpers, graders, loaders, etc., items of equipment the figures as decided are 20%, 25% and 30% respectively, for single shift, double shift or three shifts operations.

Amount of annual depreciation is evaluated by using the selected figures of fixed percentage depreciation on reduced value of equipment at the beginning of the year.

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(3) The scheduled life of equipment is decided by determining the number of years during which the depreciated value of equipment would be reduced to 1/10th of the original cost. For the above-mentioned items in (2) preceding the figure of life would be 10 years, 8 years and 6½ years corresponding to 20%, 25% and 30% annual rate of depreciation.

The figures of percentage for evaluating yearly depreciation, life in years and hours, residual value etc., for various categories of equipment under varying intensity of use have been illustrated in Appendix 8.4.

13.3.4.2 Methods of calculating depreciation

With the Declining Balance Method of Depreciation, the depreciation for any given year of the working of the equipment can be calculated from the following formula:—

$$D_1 = dC\ (1\text{-}d)n^{-1}$$

$C(1\text{-}d)^{n-1}$ being the residual value at the begining of the year, the depreciation for any year can be calculated by multiplying the residual value of the equipment at the begining of the year with the rate of depreciation.

The total depreciation at the end of any given year can be determined from the formula:—

$$D_2 = \left\{ 1-(1\text{-}d)^n \right\} C$$

Where D_1 = depreciation for the year.

D_2 = total depreciation upto the end of the year

d = rate of depreciation as a percentage;

C = capital cost; and

n = number of years.

A table showing the figures of depreciation and the residual value of a machine costing Rs. 5 lakhs, based on Declining Balance Method of Depreciation on fixed percentage basis, has been worked out for illustration. The percentage of depreciation has been taken at 20 per cent, 25 per cent and 30 per cent, based on single shift, double shift and three shifts work respectively.

Value in Rupees

Year	20%		25%		30%	
	Depreciation	Residual value	Depreciation	Residual value	Depreciation	Residual value
1st	1,00,000	4,00,000	1,25,000	3,75,000	1,50,000	3,50,000
2nd	80,000	3,20,000	23,750	2,81,250	1,05,000	2,45,000
3rd	64,000	2,56,000	70,312	2,10,937	73,500	1,71,500
4th	51,200	2,04,800	52,734	1,58,203	51,450	1,20,050
5th	40,960	1,63,840	39,550	1,18,652	36,015	84,035
6th	32,768	1,31,072	29,663	88,989	25,210	58,824
7th	26,214	1,04,857	22,247	66,742	17,647	41,177
8th	20,971	83,886	16,685	50,056	12,353	28,824
9th	16,777	67,108	12,514	37,542	8,647	20,176
10th	13,421	53,687	9,385	28,156	6,053	14,123

13.3.4.4 *Advantages of 'Declining Balance Method of Depreciation'*

In so far as Irrigation and Power Projects are concerned, introduction of 'Declining Balance Method of Depreciation' in lieu of 'Straight Line Method of Depreciation, would afford following advantages:—

1. Irrespective of the period/duration of time for which the machine is in use, a certain amount of residual value would always be indicated. According to the previous system, the residual value of equipment tended to approach the 'Zero' figure at the expiry of the predefined figure of life of the machine in hours. If the machine was to be sustained in use thereafter, the cost of depreciation was to be ignored, unless the value of the machine was reassessed on basis of the personal judgment of the user commensurate with the assessed/estimated additional useful life. Furthermore, with different figures of life adopted by different users for the same item of machine, there was no uniformity in reckoning the component of depreciation cost.

2. By this method, the depreciated value of equipment reflects more realistically the intrinsic value of the machine. At the time when repair input is least (when the machine is new), the amount of annual depreciation is the highest. The residual value at the end of any period works out to be a more reasonable figure to attract a prospective buyer to take it over, if the machine grows surplus.

In case of transfer of such used equipment to other Government Departments, the transferee generally evaluates the investment he has to make towards repair cost of the machine before it can be recommissioned on his job. If the transfer value—which will be equivalent to the depreciated value is reasonable, the transferee would not mind making additional investment in repairs of the machine. This helps in early rehabilitation/disposal of the surplus machines and consequently the idle time period without work.

3. A new machine performs more efficiently, yields more production and is least expensive on maintenance and repairs in the initial period of its life. Subsequently, as the machine ages out, the operational efficiency declines, its productivity reduces and the cost of maintenance and repairs increases sufficiently. If, as in the case of 'Straight Line Method of Depreciation, the depreciation costs are constant, while the repair and maintenance charges keep increasing, the resultant effect is visible in the increased cost of the end product as the machine grows older. If deprecition is reckoned on basis of the "Declining Balance Method", the higher amount of depreciation charges in the initial period, lesser amount of repair and maintenance input during that period, and better productivity gives a unit rate of the resultant product produced by the machine, which may be closer to the unit rate of the product in the subsequent life of the machine (when it grows old), due to comparatively much lesser amount of depreciation charges, higher cost of maintenance and repair and comparatively lesser productivity. In brief, the divergence from the average estimated cost (unit rate of the product) is minimised. Accordingly, this provides a better method of accounting for depreciation to reflect actual costs close to the estimated cost of work.

In so far as the Public Sector Undertakings are concerned, they account for the figures of actual expenditure in respect of maintenance and repair costs. If the depreciation costs are also accounted for by the 'Declining Balance Method; they will achieve the uniformity in unit rate of the product produced by the machines. This rate would be closer to the estimated rates or the rates at which the produced commodity is marketted by them.

The point is better illustrated through the graphs which have been drawn below:—

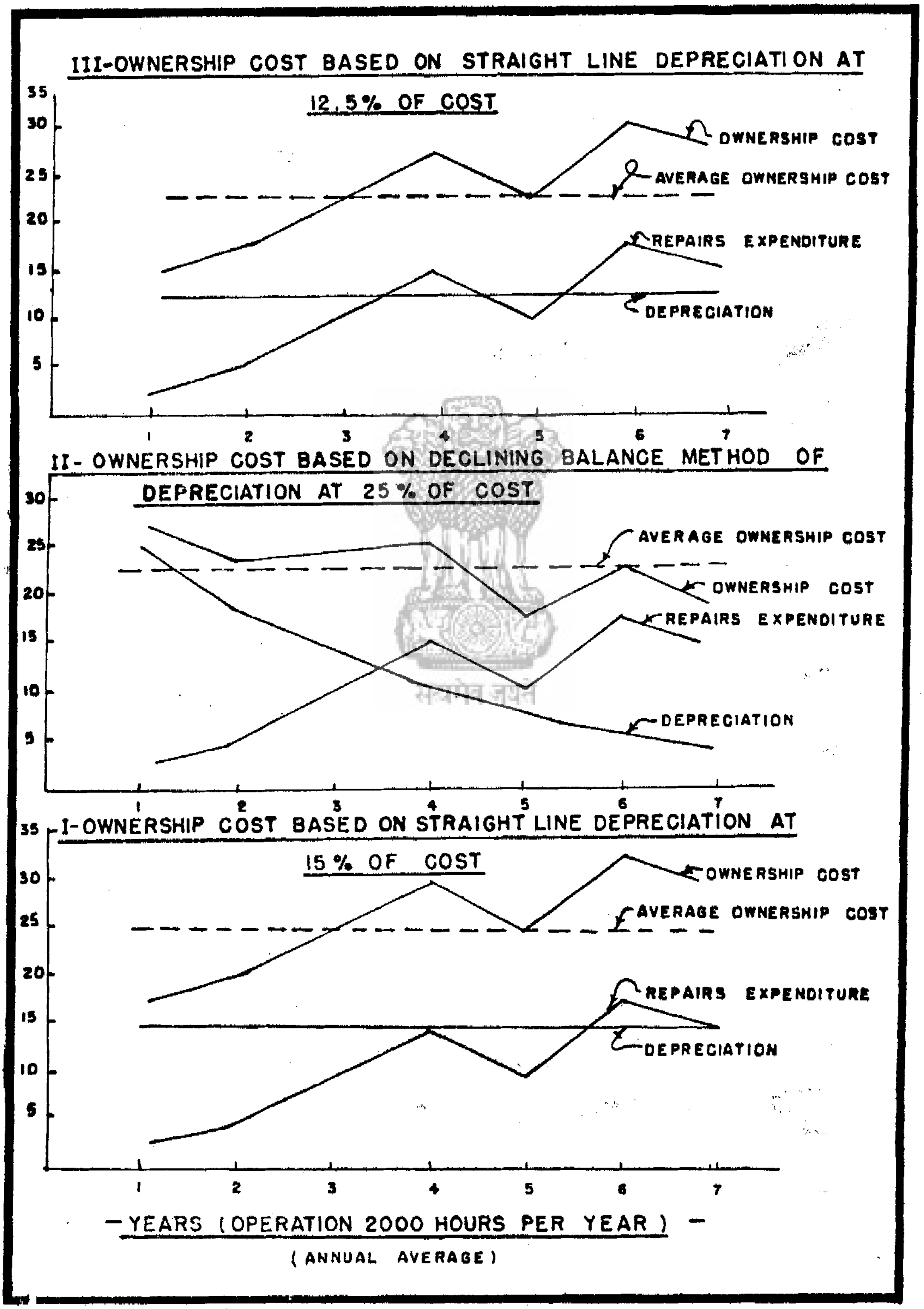
Graph I:—Shows the depreciation by straight-line method as adopted by some of the Public Sector Undertakings-15 per cent depreciation per year for life of 7 years, and average cost of repairs computed on the basis of information received from various users of equipment in relation to one item of equipment (Dumpers.)

Graph II:—Shows the depreciation by declining balance method at 25 per cent of cost and repairs cost as in the case of Graph-I above.

Graph III:—Shows the depreciation on straight-line method, but at the rate of 12.5 per cent each year for a life of 8 years and repair costs as per Graph-I above.

In each of the 3 graphs, the ownership cost line—summation of the depreciation cost and the repair cost, has been drawn and a line of average annual cost has also been drawn (dotted lines).

It may be seen from Graph-II with the declining balance method of depreciation, that there may be visible loss during the first three years of operation of machine while in the subsequent period inspite of the increasing cost of



repairs, the actual ownership cost is below the average line, which means a profit. Taking into account the fact that the machines give more production with better operational efficiency in the first half of their lives the cost per unit of commodity produced may get reduced nearer to the figure of pre-estimated average unit cost. Similarly, in the subsequent period with reduced production due to ageing, even though there is an indicated profit, the unit cost of commodity may again be closer to the figure of estimated average unit cost.

As opposed to this Graph-I indicates substantial profit in the earlier life of the machine while at the later stage there are considerable losses due to the actual ownership cost being much above the average line. With reduced production in the later half of the life of the machine the unit cost of product would remain much above the average cost line.

Graph-III has been drawn to present a case where the residual life as obtained by the straight-line method and declining balance method of depreciation is the same. In this case the depreciation rate has been taken as 12.5 per cent using the straight-line method and after 7 years the residual cost of the machine will be about 12.5 per cent which will be the residual life of the machine. This figure of residual life is nearly the same as in the case of Graph-II where declining balance method of depreciation has been followed.

It may, therefore, be stated that the declining balance method of depreciation is more realistic if the economics of operations with such construction machinery has to be clearly judged. It is a different thing to account for the element of costs, but to watch the performance of the equipment cost-wise in relation to the cost of commodities ultimately produced and marketted, it is necessary that the bookings of expenditure year after year are on a basis that may reduce the amount of variation between the average cost and the actual cost as incurred. It is therefore, desirable to adopt the declining balance method of depreciation in all sectors.

13.3.4.5 *Income-tax rules on depreciation*

To complete the thinking of the Committee on this subject of 'Depreciation', a study has also been made of the Income-Tax Rules on the subject. An extract from the Income-Tax Rules for the assessment year 1971-72, is given at Appendix 13.1. Even though the fixed percentage figure of depreciation according to the Income-Tax Act is much higher than what the Committee has adopted, the Committee feel convinced that the standards adopted for recommendation are more reasonable in relation to actual system and conditions of work in different fields of application of equipment in the country.

13.4 **Interest Charges, Insurance and Taxes**

13.4.1 *Interest Charges*

It is a general practice with Government Department not to account for these elements of costs. In so far as the River Valley Projects are concerned, interest is calculated on the total direct capital outlay to end of the previous year plus half the outlay of the year itself. The interest account is a simple debit and credit account showing on one side the charges for the interest and on the other the net revenue or deficit. A portion thereof allocable to cost of machinery is not included in the hourly ownership and operating cost of machines. This practice, however, does not determine the actual cost of the work with the machines as a separate item.

Conventionally, in the straight-line method of depreciation, the interest charges are considered on the average annual cost of investment. The average annual cost is reckoned by the formula:

$$\frac{\text{Capital cost} + (n1)}{2n}$$

where 'n' is the figure of life of the machine in number of years. As an example, for a machine whose service life is fixed as ten years, the average annual investment will be:

$$\frac{\text{Capital Cost} \times (10+1)}{10 \times 2} \text{ or } 55\%$$

of the Capital cost of the machine.

In case of decling balance method of depreciation the average annual investment is:—

$$\frac{C}{n}\left\{1-(1-d)n\right\}\frac{1}{d}$$

The amount of annual interest charges with rate of interest as 'i' therefore, is:—

$$\frac{C}{n}\left\{ 1-(1-d)^{n} \right\}$$

where C is Capital cost,

d is rate of depreciation (per cent)

n is number of years, and

i is rate of interest charge (per cent).

A table showing the investment at the beginning of the year, amount of depreciation during the year (at 20% by declining balance method) total depreciation upto the year, residual value at the end of the year, average annual investment for the years and interest charges annually upto the year at 10% rate has been worked out and given in Appendix 13.9. These figures have been worked out as a percentage of Capital investment assuming the investment as 100. Table II in this Appendix has been prepared by rounding off the figures of nearest whole numbers for convenience of accounting purposes. These are for illustration only.

In their report, the first Construction Plant and Machinery Committee had made the recommendation that interest charges should be accounted for in reckoning the hourly ownership and operating cost of equipment in accounting for the cost of work with machines. It is the considered opinion of the Committee that the element of interest charges should be duly accounted for, but based on average annual cost figures. However, for Irrigation and Power projects, this element may not be accounted for separately if the equipment is solely used on departmental works.

13.4.2 *Insurance and Taxes Etc*

In so far as the Insurance Charges are concerned, these are not accounted for, as the Government vehicles/equipment/property are not insured.

In so far as other taxes are concerned, to the extent these are payable in the process of acquisition of equipment, these make a part of the capital cost of the equipment. These are, therefore, included in the amount by way of capital cost of equipment to be depreciated. If any other taxes are payable in keeping the equipment on the road, according to any State laws enforced in the area or location of working of equipment, these would be included in the yearly running and maintenance expenditure of the machine.

13.5 **Repair Cost**

Repair cost is the main element of cost in the entire ownership and operating cost rate structure which needs proper watching and accounting, to establish the equipment economics. This is the input to the machine for keeping the machine in good condition to do the job economically.

The details in this respect have already been discussed in Chapter 8. It has already been explained in the said Chapter that from standpoint of equipment economics the repair charges are to be classified under one head as 'Repair Cost', instead of classifying the same under different sub-heads as Major Repairs and Field Repairs, as per the prevailing practice.

13.5.1 *Repair Costs as Adopted by Different Users.*

The prevailing practice for accounting of repair charges differs from user to user and from one sector to the other. The following will explain the position in this regard.

13.5.1.1 *Irrigation and Power Sector.*

It has been a normal practice with most of the Irrigation and Power Projects to account for the hourly ownership costs of equipment for purposes of debit of expenditure to the work in the following manner:—

1. Hourly Depreciation Charges = Minitial acquisition Cost, divided by estimated life in hours
= D
2. Major Repair Charges at 100% of hourly depreciation rate = 'D'.

(Note:—In some cases where the basic schedule of life in hours in relation to particular items of equipment is taken at high figures above the normal rated figures of 10000 hrs. to 12000 hrs. for machines like dumpers, crawler tractors, graders, loaders etc., the provision for major repairs may extend even upto 200% of the hourly depreciated rate or 2 D.)

In so far as the expenditure on field repairs is concerned this is shown under operation costs or direct costs.

For major repairs, a 'Major Repair Fund' is created. At any stage of service life of equipment, the total earnings under the 'Major Repair Fund' are equivalent to the number of hours of operation multiplied by the rate of provision of Major Repair costs, as indicated above. This is balanced by corresponding debits to work through hourly ownership cost of equipment at the same rate. However, the Major Repair Fund carries a certain amount of balance which is equivalent to the difference in the amount of earings in the Major Repair Fund as mentioned above, and the actual expenditure incurred in carrying out the Major Repairs to individual machines. The Major Repair Fund is generally in relation to a group of machines of the same make and model, though in some cases, the user of equipment can reckon the figures of such balances in the 'Fund' relative to each individual piece of equipment.

The amount of balance available under the 'Fund' at any time indicates whether the machine is working economically or not.

In case of field repairs no separate expense account is maintained, as the expenditure on this account is booked as direct expenses.

13.5.2.2 *Public Sector Undertakings*

In case of Public Sector Undertakings, the repair costs are directly charged to the overall cost of owning and operating the equipment as a lumpsum figure for a category of equipment-dumpers, tractors or excavators. The accounts for different makes and models of machines even in the same category are not individually detailed.

13.5.2.3 *Private Sector*

In the private sector, however, it was observed by the Committee that greater attention is paid to the account for the repair costs of individual items of equipment. Identical items of machines are grouped together for this purpose and the accounts are so maintained that it is possible to read off at a glance, the up-to-date expenditure on spare parts for that group of machines. The accounts indicate not only the daily or monthly values of spare parts issued for repair of equipment, but these also indicate the progressive cumulative total value of parts issued upto a particular period of time. Such a system enables one to determine clearly whether the cost of repairs is fairly reasonable or that it is excessive so as to warrant further examination of the case to the point of precisely determining the reasons for such excessive repairs to the machines.

13.5.3 *Disadvantages of the System of Accounting of Repair Costs of Mechines as followed by Irrigation and Power Sector.*

13.5.3.1 *Repair costs taken as a percentage of depreciation brings anomolous position*

Let us consider the following example:(The assumptions made reflect factual position as observed in different Projects.)

Project 'A' is using crawler tractors costing Rs. 5 lakhs each. The work is done in single shifts daily and the scheduled life for the tractors has been fixed at 10000 hrs. The provision for major repair cost has been made at 100% of hourly depreciation rate or at Rs. 50 per hour.

Project 'B' has identical crawler tractors in use. The work is done in two shifts per day. The scheduled life of the tractors has been adopted as 15000 hrs. The provision for major repairs based on purchase price of Rs. 5 lakhs per machine, and at the same rate of provision of Major Repair Cost, viz., 100% of depreciation amounts to Rs. 33.33 per hour.

It is evident from the above that inspite of the Project 'B' using the crawler tractors more intensively, have put up with a provision of Rs. 33.33 per hour by way of repair cost of the machines while project 'A' inspite of using the machine in single shift work, have larger amount of provision for major repairs of machines at Rs. 50 per hour.

While there is no doubt that irrespective of the extent of provision of major repair charges, at the initial stages of operation of machines, the repair costs would be much lower and the amount in the Major Repair Fund would keep increasing. What is disturbing is the amount of expenditure being booked to the work of the unit cost of the work done. If the crawler tractors were used on identical items of work under similar job conditions, by both the projects 'A' and 'B', the work on project 'A' would evidently appear to be constlier on unit rate basis. This precisely is the anamolous position resulting from accounting of the major repair costs of machines based on estimated hourly rates related to the hourly depreciation rates.

If on the other hand, the two projects had maintained a clear account of the repair costs of machines used by them, and if the rate of depreciation of the equipment was also the same, it would have been very convenient for a comparative study of unit rates of work at two places to be made. All other elements of cost being otherwise equal, it would have been possible to pin-point clearly as to why the repair costs were heavier or lighter one compared to the other.

In what has been described above, there are glaring examples of,

(a) the Irrigation and Power Projects not following the recommended life figures in Hours uniformally;

(b) not reckoning the major repair costs on actual basis for given items of machines; and

(c) accounting the major repair costs with correlation to the depreciation costs resulting in anamolous position arising as in the case of above examples.

13..5.3.2 *Balance amount available in Major Repair Fund occasionally induces the equipment owner to incur expenditure on purchase of spare parts*

As indicated in preceding Chapters of this Report, very little attempt has so far been made in establishing a scientific inventory control system for purchase of spare parts etc., by most of the users of equipment in the country. It is a normal practice to raise annual indents of spare parts for repair and overhaul of equipment on advance planning basis. In absence of detailed records of consumption of spare parts and the identity of parts used for repairs in the preceding-past-service-period of the machine, the equipment owner or the indentor is not too well-guided in properly scaling the requirement of spare parts or in establishing precisely the identity of the items that should be purchased. His experience in the work thus commands him to be judicious to some extent only in determining the size of the indent to be placed. Such guidance is, however, limited more by the availability of the funds under the Major Repair Fund as this, in any case, has to be the guiding factor for financial approval of the expenditure for the items of spare parts included in a given indent.

The earnings for the Major Repairs Found at a uniform pre-determined rate of provision in terms of rate of hourly depreciation, leave enough in reserve in the first 2 to 3 years of operation of the machine. Purchases made on this consideration result in overstocking of spare parts on projects. Even though none would readily accept the reasoning as such, to account partially for the amassing of stocks of spare parts on projects, this unfortunately is atleast the partial truth.

Again, while there is no doubt that advance planning for procurement of spare parts is the crux of the problem to sustain the machines in operation on production work, or construction work, a note of caution is clearly sounded by the tendency to over-indenting or over-stocking of the items of spare parts in this manner; and therefore, one has to clearly understand the actual requirements of spare parts commensurate with the operational life and age in service life of the machine. Besides this, the repetitive cyclic nature of repairs in relation to some components and assemblies on a machine, has also to be reckoned with properly so that unnecessary expenditure is not made in purchase of spare parts which cannot be used over long periods.

13.5.4 *Committee's Views*

Repair costs take the shape of repetitive cycles beginning with minor repairs, going up with repairs through rebuilding and ultimately touching the maximum with repairs through replacements of components. Once the components are replaced the cycle repeats. The expenditure on such repairs over a given cycle can only be expressed in relation to the cost of the machine, as it has no direct relationship to the depreciation cost.

As has been explained in Chapter 8, the major and field repairs should not be treated separately. In order to watch the expenditure on repairs of any machine the repairs should be classified under one head and all expenditure on repairs either taken up in the field or carried out in the Main Shops, should be booked under this head to have a proper watch on the equipment economics.

13.5.5 *Tyres*

In evaluating depreciation cost of equipment, the cost of tyres is not included in the figure of Capital Cost of the machine. The cost of tyres is separately reckoned for depreciation, based on a figure of life for the tyres relative to job conditions and various other factors. The procedure of determining the life of tyres after selecting the particular factors applicable in case of a given job and the attendent conditions prevailing thereon, has already been explained in Chapter 8. Judicious selection of the factors given in the said Chapter may lead to a nearly correct estimate of the life of tyres on a machine used on a given job.

In estimating the ownership and operating costs, in relation to the tyre costs, the cost of repairs to the tyres and tubes during the life of the tyres has also to be taken into account. This is generally provided for at 15% of hourly tyre costs.

In case recapping or retreading facilities are available for certain sizes of tyres, provision has to be made in that regard also. From the figures of cost for retread etc., as verified from one of the users in Public Sector Undertakings, this amounts to about 25% of the original cost of the tyres while the life of retreaded tyre is 50 to 75% of the original tyre. Hence, from standpoint of economy in tyre costs, meticulous care is to be taken to ensure that the tread wear on the tyre is not allowed to go beyond a certain point and retreading thereof is undertaken in proper time. This could be achieved through rigorous preventive maintenance inspection which is also dealt with separately under the Chapter on 'Maintenance'.

13.6 **Other Operation Costs**

13.6.1 *Operators wages and maintenance crew charges*

Since all the operational labour and other staff for operation and maintenance of equipment, is paid on monthly basis, the operational and maintenance labour charges make an item of annual expenditure, unless labour or the staff are laid off during the off-season period. This is, however, seldom done; and therefore, the expenditure on operational labour and maintenance labour (for prescribed/scheduled maintenance), has to be reckoned on annual basis.

13.6.2 *Operational Supplies*

These would be mainly comprised of fuel, lubricants and other miscellaneous items, including filter-elements, cotton waste and general routine hardware items etc. However, the sum total of expenditure on this account is related to the 'Operational hours' in a given year of work.

It is necessary to keep a watch on the expense account in this regard to judge the equipment performance. The consumption of Diesel Oil, lubricating oil on a diesel-powered machine for instance, if properly accounted for, would tell clearly the story of performance of a machine—whether the machine did actually work for the number of hours shown to have been clocked or the condition of the diesel engine on the machine is sound enough or that immediate attention is called for to be given to the performance of the diesel engine because the lubricating oil consumption etc., has gone up. The position can be better vouchsafed in this behalf, only if proper record keeping is done with regard to supplies to the machine.

Field reporting proformae have been devised in a simplified form to enable such records to be maintained properly and evaluated at periodic intervals for determining precisely if the costs are within specified limits and also if the diesel engines are performing properly on the machines. These forms are given in Appendix 13.2.

13.6.2.1 *Fuel*

In this connection, it is also necessary to indicate that a study of the fuel consumption gives relative to individual machines or a group of machines (more so in relation to individual machines), would clearly indicate whether the consumption is more than the specific fuel consumption figures or within those figures relative to the load factor for given job conditions. The load factor for some items of diesel powered equipment relative to particular job conditions are indicated in Appendix 13.3. Here again, it is to be mentioned that these would generally be used for estimation purposes and random check purposes of the actual fuel consumption figures as obtaining on a given job by particular machines. To be exact and precise, the specific fuel consumption figures have to be determined and laid down for given items of equipment, after proper tests and observations have been made on machines actually employed on the job.

13.6.2.2 *Lubricants*

It may also be indicated that for estimation of the expenditure on lubricants, greases and other such supplies, it is normal to assume that these would amount to about 30% of the cost of fuel oil used on the machine. This again, is a rough approximation for estimation purposes.

13.6.2.3 *Energy charges*

For electrically-powered machines, where the supply of electric power is from transmission lines, and not through a diesel generating set installed inside or provided with the machine, the consumption of electrical energy is to be as important as the fuel consumption in a diesel-powered equipment. The consumption of electric energy can vary substantially with the load factor in duty performance of the machine. It is not only a simple function of the installed power in the electrical equipment inside the machine. Hence, it is essential that eletric energy metering arrangements be provided in order to evaluate the test checked figure of cost that should go into the ultimate cost structure of the ownership and operating costs of an electric-powered machine.

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13.6.3 *Other consumable supplies*

There are a few other items of costs to be accounted for in addition to the factors discussed above, which have to be assessed, if the ownership and operating costs of a given piece of equipment are to be properly determined. These are the following:—

1. Conveyor belts.
2. Cutting edges on bulldozers, scraper bowls and grader blades.
3. Filters.
4. Wire ropes.
5. Batteries.
6. Bucket teeth on excavator buckets.
7. Sundry materials.

The items are such as are generally replaced or rebuilt at periodic intervals and the life tag put on each is based on the job conditions or type of materials handled or duty performed by the machines. It is, therefore, necessary to deal with each item individually so that a clear guide line is set forth for estimating the cost of these items related to operational hours of the machines, plant or equipment. In what follows is a brief assessment in this regard, itemwise.

13.6.3.1 *Conveyor belts*

Considering conveyor belts as an item which is different from the other mechanical components in the integrated conveyor system, the factor of cost in relation to conveyor belts is to be evaluated as follows:—

The life of conveyor belt is estimated in terms of 'Tons of material conveyed', or in terms of 'number of years', if the quantity of material conveyed annually is more or less a sustained figure.

The per hour cost of belts for a given operation transporting a type of material, is worked out by dividing the cost of the belt by the number of hours of life and correspondingly, the quantity of material transported or conveyed in that measure of time, whether in hours or years.

The repair costs of belts are taken at 15% of these cost figures.

13.6.3.2 *Cutting edges on bulldozers, scraper bowls and grader blades*

The cutting edges on bulldozers, scraper cate that a study of the fuel consumption figures relative to individual machines or a group of machines (more so in relation to individual mach- bowls and grader blades, have to be periodically turned, rebuilt or replaced, depending upon the severity of job conditions and the type of material to be excavated or handled. In evaluating the cost per operational hour for cutting edges, a life tag is attached to the same, in relation to the particular equipment on which it is fitted and the type of material to be handled, or the mode of operation of equipment. As an example, a bulldozer employed on spreading the material dumped in a fill area, would have much longer life for the cutting edge compared to the bulldozer working on excavation of semipervious material or removing overburden consisting of material of abrasive type. Similarly, in a motorised scraper working on removal of ripped sand-rock, the life of the cutting edge would be lesser, compared to the same scraper used on removal of clay material. Again, if the operator of a motorised scraper chooses to load the material into the scraper bowl on scraper's own power instead of resorting to filling the bowl entirely by push-loading method, the life of the cutting edge on the scraper bowl would be much lesser.

Hence, job conditions, the type of material to be handled or the mode of operation, make all the difference in the life of the cutting edges on these machines.

In estimating the hourly operating cost, the cost factor on account of replacement or rebuilding of cutting edges is also taken into account in terms of cost of the cutting edges and the life in operation, in hours, that it will last for.

13.6.3.3 *Filters*

Change of filters is done according to a prescribed schedule of maintenance. It is easy to determine the hourly cost in respect of this item which will add to the cost of operation of a machine.

13.6.3.4 *Wire ropes*

Wire ropes also have a life tag on them, depending upon the location of the wire rope in a particular 'System' on a given machine, the intensity of use of that particular system on the machine and the severity of the job condition. For a given job where the conditions of work are stabilsed, it is easy to determine through experience, the life of the wire ropes used in different locations in the systems of the machine and the cost per hour can be easily determined for accounting of the same in the operational cost per hour of the machine as a whole.

It is usual to reckon the overall requirement of wire rope for yearly indenting or periodical indenting based, on the anticipated life of the wire ropes commensurate with the length of the wire rope used in particular places on the machine.

13.6.3.5 *Batteries*

The life of batteries is commensurate with the duty to be performed and the regularity of attention paid to the maintenance of the battery through periodical recharging, the specific gravity of the electrolyte used and the climatic and temperature conditions under which the battery is to work etc., etc.

With careful attention to preventive maintenance drill, it is a general observation based on experience on part of the users that the life of a battery may be anywhere between one working season to two working seasons.

13.6.3.6 *Bucket teeth for excavation buckets*

Though it is difficult to define a figure of life for the bucket teeth on shovel/dragline buckets, it is a function of the mode of operation of the machine by the operator, generally speaking, related to given conditions of work and the type of material to be handled.

It is a common practice that the wear on the bucket teeth be allowed upto a pre-determined limit and the bucket teeth then rebuilt with proper electrodes when they can give as good a life in subsequent use as the new bucket teeth would normally give. The cost of rebuilding the bucket teeth would vary with its size. Hence, it is difficult to give a clear estimate of cost on this account. But generally speaking, the cost of conservation through rebuilding amounts to about 1/3rd of the cost of the original bucket teeth.

Evaluation of expense and cost in either rebuilding the original worn out bucket teeth, or by rebuilding them with new tips, serve to furnish the main guide line for the hourly cost to be added commensurate with the life attained with reclaimed bucket teeth. The life of rebuilt tip would be about 65% of the original life.

13.6.3.7 *Sundry materials*

These amount to a fraction of the total cost of operation of machines. Hence, a separate factor evaluation of this element of cost, based on empirical formula or thumb role is not being given. This could be judged more through experience in the course of operation of the machine over a period of one year and under given job conditions.

13.7 System of Accounting

Accounting of ownership and operating costs serve three different purposes. These are:—

1. Estimation of the cost of work on which certain items of equipment will be employed according to a pre-planned programme.
2. To determine precisely the actual expenditure on running and maintenance of the machines and the element of cost of depreciation.
3. To create a clear record of cumulative costs accruing to the equipment owner so that he can determine the economy of sustaining a given machine in operation. Briefly speaking, this serves the purpose of studying "Equipment Economics."

The significance of evaluation of individual elements on costs has, therefore, to be clearly considered in relation to each item. This is discussed in what follows. This would generally reflect the process of the estimating the cost and evaluating actual cost in relation to each element.

13.7.1 *Basis of Evaluating Elements of Costs for Estimation of Costs of Work*

The "Ownership Costs" will generally be of variable character, if the "Declining Balance Method of depreciation" is adopted, as the depreciation costs would vary from year to year. The cost of spare parts in the repair costs of machines, which is an important element in the 'Operating costs of the Machine', will normally vary with the age of the machine, year after year. The other elements of operating costs, consumption of fuel and lubricants maintenance supplies and other operating supplies, the labour costs on operation, maintenance and repair of equipment however, could be defined relative to the work pattern (by number of shifts per day) and the number of machines in use (average numbers) every year. However, an integration of the total costs under these separate groups of elements of costs, has to be so done that the fundamental basis of assessment of estimated cost of work is not seriously upset. The main aim is to evaluate, the overall costs of a given item of work on which the machines are employed-from the stage of commencement of that particular work to the stage of completion thereof.

Two types of cases would be involved in such assessment. These are, (1) where the entire life of a machine's will be spent on the job; and (2) where only a part of the scheduled life of machine is used on a time-bound programme. The method of determining the hourly rate of ownership cost in either case would be as follows:—

13.7.1.1 *Where life of the machine is spent on the job*

In case the machine has to spend its entire life on certain operations and a figure of salvage value has been prescribed in relation thereto, the evaluation of the hourly ownership cost figures would be simple. This would amount to reckoning of the capital investment to be written off over the defined period of life of the machine to account for depreciation, and dividing this element of cost by anticipated hours the machine will clock in their life-time operation.

13.7.1.2 *Where the entire life is not spent on the job*

In case the machines are not expected to spent their entire span of life on a given item of work, the exercise to be carried out would be slightly different, viz.,

(1) Define the period of work in number of years for which the machines would be required to be in use to complete a given item of work.

(2) Make an assessment of the total amount of depreciation (by the Declining Balance Method on fixed percentage basis) that will have to be accounted for during that period for the particular machines to be used.

(3) Estimate the number of machine-hours to complete the work in relation to each item of equipment.

(4) The total cost of depreciation for the corresponding period of operation of machines, divided by the machine hours for given item of equipment, would provide the figure of hourly ownership cost to be reckoned with.

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13.7.1.3 *Interest charges*

In case the interest charges are also to be taken into account, in relation to use of equipment which is used for a part of its life on a given job, the annual average investment will be determined from the formula given at 13.4.1. corresponding to the number of years the equipment would be in use on the job. This would be added to the estimated cost on account of depreciation and the estimated hourly ownership cost rate inclusive of interest charges determined by dividing the sum total figure by the estimated machine hours to complete the work.

13.7.2 **Evaluating Operating Cost**

With regard to the operating costs the items to be included therein would be the following: —

1. Spare parts for repairs of machines.
2. Tyre and tubes for replacement and repairs.
3. Labour for repairs of the machines.
4. Workshop charges.
5. Labour for operations and maintenance of machines.
6. Operating supplies-POL items, other materials including wire-ropes, cutting-edges, bucket teeth, filters, batteries, hardware items etc., etc.

The hourly rate of spare parts consumption can be determined as follows:—

Corresponding to the machine hour to be spent on the job, the total value of spare parts that will be consumed in repairing the machines for proper working can be scaled out (guidelines given at Appendices 8.7 and 8.8). The total value of spare parts so scaled out divided by the hours the machines would operate on the job will determine this hourly rate. The expense on account of replacement and repairs of tyres can be evaluated commensurate with the total working hours the tyred equipment will be used on the job and the hourly cost estimated on similar basis as for equipment.

The strength of labour to be employed on operation, maintenance and repair of equipment being known, consistent with the pattern of work in the field (single shift, 2-shifts or 3-shifts) or the establishment in field and main workshops for repairs etc., the total cost on account of annual wages of the labour, including overhead costs that may accrue in the shops can be evaluated. Similarly, based on an estimate of anticipated working hours with equipment in a particular year, the estimate of total costs on account of operating supplies—POL items can be clearly made. The cost of materials miscellaneous items, like cotton waste, sealing compounds, cleaning compounds etc., can also be similarly evaluated.

In relation to items like cutting edges, wire ropes, batteries, filters, which normally have a life-tag rating attached to each, the total expense commensurate with the working hours, as estimated, can also be properly evaluated. The sum total of all these elements of costs can then be related to the total machine hours covered by the estimate in relation to a group of machines of the same make and model, and the hourly operating costs properly figured out.

13.7.3 **Overhead and Supervision Charges**

In so far as the overhead and supervision charges are concerned, the Public Sector Undertakings account for it in their monthly expenditure statement. In the Irrigation and Power Sector, the overhead charges are accounted for separately as a charge on the total expenditure on the work as a whole. No separate charge on this account is taken into account for apportioning the expenditure to different items of work on which the machines are employed. It is only when the equipment is let out on hire charges basis to private agencies, that the element of overhead charges is taken into account for determining the hourly rental rate for individual item of machines. This has been discussed in Chapter 9.

13.7.4 **Estimated Hourly Ownership and Operating Cost for Given Items of Equipment**

For the purpose of estimating the unit cost of work it may be necessary to estimate in advance the probable hourly cost of owning and operating the equipment. It is, however, necessary that such estimation should be done on a nearly actuals basis so that there may not be a wide divergence betwen the estimated cost and the actual cost of operation.

The basic exercise in the estimation of hourly ownership and operating cost could be worked out as follows:—

C—Capital cost of equipment.

d—Rate of depreciation

H—Life spent on job in hours.

i—Rate of interest.

n—No. of years of life of equipment spent on the job.

R—Factor indicating number of items of cost of equipment as a provision for repair charges (labour excluded) during service life of equipment spent on the job.

F—Fuel cost/hour of operation.

L—Labour cost per year (operation & Maintenance).

T—Cost of tyres.

h—Life of tyres in hour.

r—Factor of cost of tyres as a provision for repair cost of tyres.

Ownership cost per year

Depreication— $\left\{\frac{C}{n}\quad 1-(1\text{-}d)n\right\}$

Interest charges if leviable — $\frac{C}{n}\left\{1-(1-d)^n\right\}\times\frac{i}{d}$

Ownership Cost/Year

$$=\frac{C}{n}\left\{1-(1-d)^n\right\}+\frac{C}{n}\left\{1-(1\text{-}d)^n\right\}\frac{i}{d}$$

$$=\frac{C}{n}\left\{1-(1-d)^n\right\}\quad(1+\frac{i}{d})$$

When life is spent on the job the expression

$\left\{1-(1-d)^n\right\}$ becomes 0.9

So ownership cost/year

$$=\frac{C}{n}\left\{0.9\ (1+\frac{i}{d})\right\}$$

Ownership cost per hour $=\frac{C}{H}\left\{0.9\ \ (1+\frac{i}{d})\right\}$

Operating Cost per hour:—

Repair Cost (Labour excluded) $=\frac{RC}{H}$

Fuel Cost/hour = F

Lub. oil/hour and Sunday items = 0.33 F

Labour Cost/hour . . . $=\frac{L\times n}{H}$

Tyre cost, if any/hour . . $=\frac{T}{h}$

Tyre repair cost per hour . . $=\frac{rT}{h}$

Total operating cost $= F+0.33F+\frac{Ln}{H}+\frac{T}{h}+\frac{rT}{h}+\frac{RC}{H}$

$$=1.33F+\frac{T}{h}(1+r)+\frac{Ln}{H}+\frac{RC}{H}$$

Ownership operating cost/hour

$$=\frac{C}{H}\ 0.9\ (1+\frac{i}{d})+R+1.33F+\frac{T}{h}(1+r)+\frac{Ln}{H}$$

13.8 Accounting

The suspense operation account would mainly include operation of construction plant and equipment which ultimately will be cleared through monthly debits to the Permanent Account—the account of the main work(s) on which the machine is employed.

13.8.1 *Present system*

In order to clearly illustrate as to how the ownership and operating cost of equipment will be accounted for, without serious departure from the normal and conventional accounting system followed mainly by the Irrigation and Power Projects, the steps involved in the existing system are explained below—(System as adopted in Beas Project).

13.8.1.1 *VI Special T&P.*

The cost of plant and machinery on procurement is debited to Head VI Special T&P. The amount under Special T&P is reduced as the equipment is used on the work, the depreciation being charged to works and credited to Special T&P. On completion of the work the sale/transfer value as realised is also credited to

Special T&P. The balance amount is then finally charged to this Head. The above is illustrated by the figures given below:—

VI SPECIAL T&P.

(A)	Capital cost . .	Rs. 2,000 lakhs
(B)	Credit . . .	
	(i) for Depreciation .	Rs. 1,150 lakhs
	(ii) For sale Proceeds .	Rs. 750 lakhs
		Rs. 1,900 lakhs

Net chargable under VI Special T&P A—B=Rs. 100 lakhs.

The adjustment for depreciation is done every quarter on a uniform hourly rate basis on the assumed life.

13.8.1.2 *Manufacture estimate*

For working out the use rate of machines, an estimate is prepared at the beginning of each financial operation of a machine will work but during the ensuing financial year. This estimate is framed like a manufacture estimate, the idea being to evaluate the cost of manufacture—in this case the cost of operating the machine. This estimate is divided into two parts, one known as the "Operation" and the other as "out-turn." Under the heading "Operation" are brought in all elements of expenditure which are expected to be incurred for the operation of the machine. These are sub-divided into direct and Indirect charges, as below:—

(A) *DIRECT CHARGES*

- (i) Direct labour
- (ii) Fuelling service
- (iii) Lubricating service
- (iv) Fuels and lubricants
- (v) Miscellaneous supplies Filters etc., and small tools.
- (vi) Running repairs
  - (a) Shop charges
  - (b) Spare parts.

(B) *INDIRECT CHARGES*

- (vii) Depreciation
- (viii) Major overhauls and heavy repairs.
- (ix) Tyres and tubes replacement—in the case of machines having tyres and tubes fitted to them.

The entire expenditure on these Heads is worked out on the assumption as to be number of hours for which the machines would be put into use during the year, and the hourly rate of operation is determined.

The provision for running repairs is made at a certain percentage of the Depreciation charges. The depreciation as explained earlier, is worked out with reference to the cost of the machine divided by its life, i.e. the number of hours the machine will run during its life as determined by the competent authority. The provision for major overhauls and heavy repairs is made at a certain percentage of Depreciation. In the case of tyres and tubes, the provision is made again with reference to their cost divided by their life (hours/K.Ms.).

The provision of major overhauls and repairs is made at fixed percentage in order to pass on the expenditure to the works on a uniform rate throughout the life of the equipment.

The provision for tyres and tubes replacement is made for the same reason as in the case of major overhauls and heavy repairs. The tyres and tubes are not taken into account along with the capital cost of the machine because these wear off faster than the machine.

When the machine is actually put into use, the number of hours and the work/works on which it is used is recorded in its log book. This log book is closed at the end of the month and an abstract is prepared thereon to show the total number of hours it worked during the month and the work/works on which it was used. The debit for the use of the machine on work/works during the month is then passed on to the concerned work/works through a transfer entry and the manufacture estimate for the machine is credited.

13.8.1.3 *Adjustment of accounts*

So far as the actual expenditure on the working of the machine is concerned, the actual cost under sub-heads (i) to (vi) under Direct charges, is debited to the manufacture estimate for the working of the machine. The element for Indirect charges is also debited to the manufacture estimate with reference to the actual number of hours clocked by the machine during the month. It has been explained earlier that in the case of Depreciation, when the Depreciation charges are debited to the manufacture estimate for the running of the machine, the credit therefor is given to VI Special T&P. Similarly, in the case of major overhauls and heavy repairs as well as for tyres and tubes replacement, when debit is given to the manufacture estimate for the running of the machine credit therefor is given to VI Special T&P. For this purpose, another special head is credited under the main Head VI Special T&P. To this Head is credited all the debits given to the works for major overhauls/replacements etc. and correspondingly it is to these sub-Heads that the cost of actual expenditure as is incurred on the major overhauls/replacements etc., is booked. This is illustrated below:—

VI SPECIAL T&P.

(A)	Capital cost	Rs. 2,000 lakhs
(B) (i)	Running and carriage T&P for which depreciation account is kept .	Rs. 800 lakhs
(ii)	Repalcement of tyres & tubes	Rs. 50 lakhs
	Sum total (A+B) .	Rs. 2,850 lakhs
(C)	Credit	
(i)	Depreciation . . .	Rs. 1,150 lakhs.
(ii)	Sale proceeds . .	Rs. 750 lakhs.
(iii)	Credit for running and carriage for T&P, heavy repairs and overhauls of T&P, for which Depreciation account is kept. .	Rs. 800 lakhs*
	(*This correspondence to the provision made at B(i) above)	
(iv)	Cost for replacement of tyres and tubes . .	Rs. 50 lakhs@
	(@This correspondence to the provision made at B (ii) above)	

Net charged under Special T&P=A+B—C=Rs. 100 lakhs.

13.8.1.4 *Major repairs and tyre-tube replacement estimate*

For keeping an account of expenditure on major overhauls and heavy repairs, as also on tyres and tubes replacement, annual estimates for this purpose are prepared. These estimates are prepared for a group of machines of the same make and model. These estimates are based on the credit which the machines are estimated to obtain during the course of the year under the Head VI Special T&P—C(iii)/(iv). The actual expenditure incurred on the major overhauls and heavy repairs/tyres and tubes replacement during the year is debited to the Head VI Special T&P—B(i) and (ii) respectively. The intention is that the expenditure on this account will be equal to the amount, debit for which has been passed on to the works. These estimates are not prepared as manufacture estimates, but are treated like other estimates for works. Any excess of expenditure over the estimated amount in the case of these estimates is regularised under the normal procedure applicable for estimates for works. While these estimates are framed for the number of machines of the same make and same model, an account is, however, kept of the actual expenditure incurred on each machine individually during the year. This enables the authorities to know the expenditure incurred on major overhauls and special repairs/tyres and tubes replacement *vis-a-vis* the amount debited to the works on that account through the Manufacture Estimate of the machines.

The difference between the "running repairs" and the "major overhauls and heavy repairs" is that the former are debited directly to the manufacture estimate of the machines for the year for which charges on their account are incurred. But in the case of the latter, the difference between the actual expenditure on major overhauls and heavy repairs/tyres and tubes replacement and the element of cost on that account, that has been passed on to the works, is carried over from year to year till the machine is finally scrapped or otherwise disposed of. A detailed account to show the depreciated value of each machine, the major overhauls and heavy repairs reserve it has earned and the expenditure that has been incurred on that account thereon and similarly the tyres and tubes replacement reserve that has been earned and actual expenditure incurred on that account, is maintained in a separate register.

13.8.1.5 *Closing of Manufacture Estimate*

The manufacture estimate for the running of the machine is closed at the end of the year, generally, in the month of September by which time all the debit and credits are received. At the time of closing, all the operation costs are summed up and similarly the total credit gained for the out-turn i.e., number of hours the machine has worked multiplied by the hourly use-rate, is found out. The total of the operation cost and the total of the out-turn revenue should tally. If the out-turn revenue is less than the operation cost, it means that the machine has run at a loss. Similarly, if the out-turn revenue is more than the operation cost, it means that the machine has run at a profit. The summary of the operation costs and the out-turn revenue are put up to the competent authority for orders. That authority may order that the difference between the operation and out-turn may be adjusted by revising the rate of out-turn and raising extra debits/credits to the works on which the machine worked during the year. Alternatively, the difference between the operation and the out-turn may be adjusted in the accounts as a loss of revenue if the out-turn falls short of the operation cost or as a profit-- receipts and recoveries on capital account if the out-turn was more than the operation cost. The record of the working of the manufacture estimates is kept in a Register of manufacture and a specimen for track-type equipment is given in Appendix 13.5.

The interest on capital value of the machine is not taken into account either as a Direct or Indirect charge while working out their use rates.

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13.8.1.6 *Spare parts*

The spare parts used on the machines are initially purchased on Stock and as and when these are issued for the repair of the machines, the Stock suspense Head is credited and the estimates for repairs of the machines is debited.

13.8.2 *Observations of Committee on the Existing System*

A close scrutiny of the points made in the preceding note on the actual accounting system adopted by the Beas Project relating to "Ownership and Operating Costs of Equipment" would reveal the following:—

(1) In respect of investment on equipment referred to as 'Capital Cost', the credit to Head, 'VI Special T&P', is, (i) the amount of depreciation charges as actually debited to the works; and (ii) the amount of sale proceeds (on estimated basis) as expected to be realised on ultimate sale thereof when it is no longer required.

Whereas the method of reckoning depreciation would not bring about any change in the method of apportioning the amount of depreciation charges (actually debited to the works), to a final head of account, in so far as the amount of sale proceeds is concerned, the figure can be determined more realistically by the Declining Balance Method of Depreciation (as explained in para 13.3.4.4., page 13-12).

(2) The debit to works in respect of major repairs are made on estimated basis---at a predetermined hourly rate and for the total number of hours any machine is used on the works. This expenditure on works is balanced by passing on credit to Head 'VI Special T&P' upto an equal amount. Hence, it is evident that both the debit to work and credit to 'VI Special T&P' are not on actuals basis.

Even if it is contended that both the debit and credit must balance each other, this is only a notional way of doing this. This could be achieved with similar convenience if the actual expenditure on major repairs is accounted for by debit to works and credit to 'VI Special T&P' on annual basis. Afterall, the imbalance between the actual cost of work and the estimated cost of work can be determined only when the job is finally completed.

(3) The system reveals that even though the debits and credits are fully balanced, a notional reserve fund is created (on estimated basis), for meeting the future requirements of major repairs on equipment. The amount in the reserve fund, as such, provides the monetary limits upto which expenditure can be incurred in future on major repairs to equipment.

If a clear estimation is done initially of the total expenditure likely to be incurred on repairs to equipment for the period for which it will be used on the job (according to the estimated machine hours taken into account when the estimate for works is being prepared), the upper limit of the expenditure on this account for the duration of the works, for repairs to equipment, would be clearly defined. Moreover, the annual expenditure and the cumulative expenditure year-after-year upto the end of a year, would enable one to clearly assess the balance amount that would be still available at any time by way of provision for further repairs to equipment.

The present system, as such, to account for expenditure on major repairs and creating the reserve fund for repairs is a welcome consideration if the equipment is let out on hire basis to contractors; but in so far as the departmental work is concerned, it becomes necessary that the actual expenditure, as incurred, should be accounted for under proper Heads. Afterall, cost records are intended to reflect actual costs for purposes of job control and future estimation. There has to be no arbitrary shifting of costs, from items showing cost over-runs to items showing costs under-runs, to present apparent balance with the 'Control Estimate'. Arbitrary advance lump-sum distribution of expenses, which tend to minimise accounting efforts but distort current cost accounts by over-writing the cost of items not yet used on works, or to reckon amount of expenditure on notional basis (at present defined estimated rates), is to be avoided.

Evidently, the present system is designed to reflect a uniformity in the unit rate of work on day-to-day basis. Certainly this can never be the case in actual practice. The actual rate of work done by the machines can be determined only after the work is completed; and this is assessed in terms of actual expenditure in relation to the measure of quantity of work done.

The figures of actual expenditure, besides affording the convenience of comparative study of the provisions made in the 'Control Estimates', also provide for the convenience of judging the 'Equipment Economics'. Hence the emphasis has to be on accounting for expenditure on all items on actuals basis only.

(4) Even though the present system provides for balancing the estimated expenditure on major repairs by debit to works and credit to 'VI Special T&P', the value of spare parts is accounted for under head 'Stock Suspense'.

Different opinions have been expressed in the matter of classification of the cost of spare parts whether under head 'VI Special T&P,' or under head 'Stock Suspense'. On some projects like Hirakud Dam Project, the Salandi Dam Project, etc., the items of spare parts were classified under 'VI Special T&P'. The contemporary thinking, however, is to list the expenditure on this account under head 'Stock—Suspense'.

This is principally based on the consideration of convenience in accounting. However, to introduce the element of affective control on expenditure on spare parts, it becomes necessary to identify the item of 'Spare Parts' by classifying it under a separate sub-head under the main head "Stock Suspense". This is accordingly done in practice by some of the Projects. It is essential that all users of equipment follow this practice.

Reserve Stock limits are generally prescribed for the "Stock" as a whole on a project. It would now be necessary to prescribe the reserve stock limit separately for the item of "Spare-Parts". This will be useful for servicing the required purpose, only if the reserve limit is prescribed before the beginning of the financial year. The Committee has observed that some times the reserve stock limits have been got approved from the competent authority on ex-post-facto basis only in retrospect for a number of years. Such action serves only to fulfil the mandate of a set of rules and is not of much consequence from stand-point of control.

The committee have also observed that while every project estimate includes a clear assessment of the total requirement of equipment (by value and particulars of machines) no indication is made, except in some exceptional cases, about the value of the spare parts that would be provided for running, maintenance and repairs of the machines. This is possibly due to the fact that the hourly Ownership and Operating costs of equipment include the element of cost of repairs, which also includes the cost of spare parts required to maintain and repair the machines. Since the works receive debits based on hourly ownership and operating cost of equipment, it is taken as implied that expenditure on repairs and spare parts is provided for in the total estimated cost of work.

Since the spare parts make a major items of expenditure, it is necessary that an estimate for total requirement of spare parts for the particular machines included in the project estimate

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should be clearly defined corresponding to the estimated service period of the machines on the job.

Another consideration that arises is the one relating to "Obsolescence" in respect of spare parts. Whenever a machine gets obsolete, most of the spare parts for that machine also become obsolete. Only such items, as are interchangeable with their counter-parts on machines of other makes/models and categories, can be conveniently used while the remaining items get to be 'Dead Stock Items'.

The 'Dead Stock Items' also include such items relating to machines which are not obsolete; but such machines may not be in use elsewhere. Hence, such parts may not find a ready market.

Keeping in mind the technological advancement in the past decades in the sphere of manufacture of earth moving machines and other construction plant and equipment as explained in Chapter 1, it may be expected that with the rapidly changing models of equipment the number of items of spare parts that may grow obsolete may keep getting larger over the time. In fact, even in the current models of machines, the technical design changes entail replacements of some of the parts by new ones. Most often conversion kits have to be purchased for such replacements introduced by the principal manufacturers of equipment. Some of the parts previously purchased with the equipment or in the initial stages of its operation also therefore, become obsolete.

Hence obsolescene has to be taken into account.

The Committee have also made a study regarding value of stocks of surplus spare parts available with some of the completed Irrigation and Power Projects in the country, which have remained unsold for a long time. On the Bhakra Dam Project the value of such spare parts is Rs. 27 lakhs. Some portion of surplus spare parts, which was earlier transferred to one of the projects is still lying unused. The total value of such items may be reckoned at Rs. 50 lakhs approximately.

It has also been verified that the total value of spare parts received on the Bhakra Dam Project was Rs. 8.2 crores approximately. Thus the value of 'Dead Stock Items' makes about 6% of the total receipts.

The Committee have also gone into the subject of inventory holding costs in respect of spare parts. It is conventional to include therein the element of cost on account of obsolescence at 5%. It is, therefore, their view that provision should be made in the project estimates on account of obsolescence in relation to spare parts upto 5-7% of the total estimated cost of spare parts corresponding to the service life of equipment on the job. The lower limit of 5% would be relevant to the spare parts for indigenous equipment, while the figure of 7% would relate to spare parts of imported equipment.

Further more since none can ever estimate precisely the total requirement of spare parts for construction plant and equipment mainly earthmoving machines and other motorised equipment, it is inevitable that on completion of the works where such equipment will be in use, a certain amount of spare parts will be left as balance besides the possible 5% 'Dead Stock Items'. This additional left-over items would, however, be of "Markettable Nature". It is the Committee's view that such left-over useful parts may be reckoned at 10% of the total requirements. Accordingly, therefore, in estimating the total value of spare parts for making a provision in the project estimate, an allowance should be made on account of residual stock at 15% (5% for obsolete items and 10% for useful items).

Based on the above considerations the following procedure of accounting system on Irrigation and Power Projects is recommended.

13.8.3 *System Recommended*

Working out the ownership and operating cost per plant hour for analysis of rates for project estimates has already been explained in para 13.7.1.

For accounting purposes these rates have to be analysed slightly differently with the main purpose of charging the actual expenditure incurred to the works every year simultaneously keeping such expenditure as close as possible to the estimated rate.

In order to achieve this objective the estimates of ownership and operating cost of the machine or a group of machines has to be prepared every year.

13.8.3.1 *Ownership and Operating Cost per Plant Hour on Yearly Basis*

(a) *Depreciation*

The amount of depreciation to be accounted for in relation to a given piece of machine for a particular financial year, can be determined by the following steps:—

(1) Define the pattern of work one shift, 2 shifts or three shifts daily basis.

(2) Select the corresponding rate of annual depreciation, viz., 20%, 25% and 30% respectively (for those items of equipment for which the rates are defined to be so), or corresponding figures as fixed for other categories of equipment as per Appendix 8.4.

These amounts can be readily evaluated by reference to ready reckoner tables prepared immediately on receipt of machine on the project taking into account the date of its first commissioning. Instead of the tables, a graphical representation could also be made and the yearly components of the amount of depreciation scaled out from such graphs for preparing the annual amount of depreciation relative to individual machines.

Even otherwise, the residual value of the items of equipment at the beginning of the year multiplied by the depreciation rate selected will give the depreciation for the year.

(3) For the group of machines covered by a particular estimate, sum up the amount of depreciation as calculated for individual machines in (2) above.

(4) Determine the anticipated hours of work on annual basis for the group of machines.

(5) The hourly rate of depreciation could be determined by dividing the figure at (3) by (4) above.

(b) *Repair Charges*

(i) To have an affective control on expenditure on repairs to equipment, a sub-estimate for repairs and overhaul of equipment will be prepared annually.

This estimate will be based on the provisions for repairs made in the annual estimate of "Ownership and Operating Cost of Equipment."

The sum total of the expenditure incurred during the year against this sub-estimate will be transferred at the end of the year to the annual estimate of, "Ownership and Operating Cost of Equipment."

(ii) In relation to expenditure on tyres and tubes whether by way of cost of replacement thereof or on their repairs, a similar sub-estimate will be prepared annually; and the total expenditure incurred during the year will be transferred to the annual estimate of "Ownership and Operating Cost of the Equipment" at the end of the year.

(c) *Tyres—Costs*

Separate life figures are indicated for tyres used on heavy earthmoving machines. The cost of tyres, is not included in the capital cost of equipment and is depreciated separately based on such assumed figures of life. The hourly ownership and operating expense of individual items of tyred equipment include an hourly charge for depreciation of tyres. In addition to depreciation, a provision of 15% of the hourly depreciated cost is taken towards repair charges. This is also included in the hourly ownership and operating costs.

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(d) *Operational Charges*

The operational charges would include operational labour, operational supplies, maintenance labour and maintenance supplies and any other sundry materials used in operation and maintenance of the machine included in an estimate. The sum total of the expenditure on this account for the year as a whole, divided by the anticipated working hours as estimated, will give the hourly charge on this account.

An example of the ownership and operating cost per plant hour on yearly basis has been worked out and given in Appendix 13.6.

13.8.3.2 *Booking of expenditure*

The annual estimate of Ownership and Operating cost of the machine or a group of machines will thus comprise anticipated expenditure on depreciation, repair charges, tyre cost and operational charges. The total of these estimated charges divided by the number of hours the machine or the group of machines covered by the estimate are expected to run during the year, will give the figure of hourly rate of Ownership and Operating cost. Booking of expenditure to various items of works, on which the machines are used, will be made on this hourly rate basis for the number of operational hours on the work.

In determining the figure of hourly use rate the expected hours of operation of the machine during the year will be taken into account. However variations in the total operational hours could occur during the year due to:—

(i) Equipment remaining idle for want of work.

(ii) Equipment remaining under repairs for certain period.

(iii) Some machines getting commissioned on the job in mid-working season and there being no opportunity for the machine to work for the total period for which the annual estimate was made.

(iv) The pattern of work on the project getting changed due to administrative reasons or for any other reason if the work is initially being done in three shifts. and suddenly it is decided to do this in two shifts or in single shift or *vice versa.*

This will have a direct effect on the depreciation charges. Accordingly the amount of depreciation charges included in the Ownership and Operating Cost estimate will undergo a change. In order that a common denominator is used for determining the rate of depreciation applicable (by Declining Balance Method), which may be rationally applied in all cases of the type mentioned in (i) to (iv) preceding, it may be only proper to go by the intensity of use of the machine on the job during the year. In Chapter 2 the schedule of annual hours for one shift, two shifts and three shifts operation of equipment has been defined. The figures as indicated therein are as follows:—

(i) One shift daily basis, 1000 hours to 1700 hours per year.

(ii) Two shifts daily basis, 1800 to 2800 hours per year.

(iii) Three shifts daily basis, 2400 to 3600 hours per year.

Considering that the possible level of utilisation of equipment corresponding to the indicated figures of schedules would be 75% to 85% (the optimum attainable), it is felt that the following procedure be adopted assessment of hourly rate of depreciation during the year relating to the estimates:—

(i) If the estimated annual figures of working hours lie within or upto 1400, the rate of annual depreciation may be taken corresponding to figures for one shift work.

(ii) If the anticipated working hours are estimated to be 2200, the rate of depreciation may be taken corresponding to two-shifts work.

(iii) For the estimate of anticipated working hours exceeding 2200 per year, the rate of annual depreciation may be taken corresponding to three shifts work.

The main purpose in defining the limits of annual working hours as above, is to remove any difficulties that might arise in selecting the figure of rate of annual depreciation due to contingencies explained above. After all, the intensity of use of equipment is to be the main criterion in the rate of consumption of capital investment.

It must, however, be emphasised that in selecting the figure of percentage of depreciation, the pattern of work—whether one shift, two shifts or three shifts per day, is to be the main guide. Idle time depreciation for machines which cannot be used during a year for any reason, or which clocked number of hours less than the basic figure of the annual schedule of hours on single shift basis, will be at rates corresponding to one shift work per day.

Under the above system, the exact amount of depreciation earned by a machine would be known only at the end of the year. Accordingly it would be necessary to make adjustments in respect of depreciation costs at the end of financial year.

13.8.3.3 *Adjustments*

At the end of the financial year, the total of the actual expenditure under the various sub-heads mentioned in para 13.8.3.1 may be summed up. The amount of debit passed on to various works, on which the machine worked during the year (based on the hourly rate worked out at the beginning of the year) be then worked out and the two compared. If there is any difference between the total expenditure on account of Onwership and Operation costs and the total debits passed on to works necessary adjustment may be carried out to the required extent in keeping with the provisions under article 163 of Account Code.

1.3.8.3.4 *Monthly cost abstract*

For purposes of judging equipment economics, a separate comparative study will have to be made in respect of the estimated and actual expenditure on account of repairs, operation and maintenance costs. The idea is to determine if the machine worked efficiently for anticipated number of hours as included in the estimate was not subjected to extensive repairs beyond those envisaged when preparing the estimate, the consumption of P.O.L. and other materials on hourly basis was not in excess or short of the figures initially assumed for estimation purposes, and the labour costs per hour were not much divergent from the costs earlier estimated. Such a study would enable one to localise the excess or short-fall in individual segments of the total cost structure and thur help in taking corrective, action in the particular area where the excess of short-fall could be accounted for due to some specific reasons. such method of analysis would help in controlling the financial estimates in subsequent years in a better manner.

In order that the yearly amount of expenditure on actuals basis is as correct as it should be, monthly accounts in this respect have to be prepared with care. For this purpose, the accounting may be done as per proforma proposed in Appendix 13.7. This proforma would relate to all machines operating in one estimate. The speciment proforma gives an illustrative exampel of a combination of machines included therein. This is for guidance only.

13.8.4 *Equipment economics*

As explained in details in para 8.3.6. of Chapter 8, the economics of retaining a piece of equipment for use on any works is judged by the maintenance and repair costs on yearly basis and on cumulative cost basis, year after year. For this to be possible, a separate account is to be maintained in respect of the each element of cost.

The depreciation costs and maintenance and repair costs, when integrated, give a clear idea of the variations in amounts of annual expenditure on the machine to keep it going as a production tool. Simultaneously, the productivity of the machine is also measured and recorded. This can be done in terms of number of hours of operation of the machine on annual basis, provided such recording of operational hours is done correctly. If the productivity of the machine can be measured and recorded in terms of units of work done during the year, this would be a better way of judging the performance of the machine. Since, however, the units of work done by the machine in a year would vary with many other factors—the haul distance in case of dumpers, the type of material excavated by a shovel, the nature of dozing work done by a tractor-dozer etc., a common yardstick would be the extent of utilisation of equipment in number of operational hours.

Once a clear tabulation is done of the elements of costs referred to above, and the hourly costs determined based on the operational hours, one can judge as to whether or not the equipment is performing economically, specially when similar evaluation would be possible in relation to any substitute or proposed replacement machine. No doubt, the cost of the new machine, its size and productive capacity would have also to be taken into account *vis-a-vis* specifications of the machine to be replaced. The exercise for determining the final economy can be completed with the available cost and performance data in the manner explained in paras 8.3.6 and 8.3.7 of Chapter 8.

13.8.5 *Record Keeping*

Record keeping is the back-bone of a good accounting system. In relation to proper accounting of the total expenditure on owning the machine or running and maintenance thereof, we have to account for the actual figures. As already stated in earlier paragraphs, some element of cost could be of the nature of annual costs (depreciation, interest charges, operators' and maintenance crew wages), while the operation supplies cost as well as the expenditure on other items with life-tags on them would be on actuals basis and directly related to the operation hours of the machine.

Furthermore, the repair cost would involve the element of spare parts costs and the labour charges. Even though the labour charges would be on annual basis the distribution of the total expenditure of labour for repairs of machines would have to be allocated and apportioned to individual groups of machines. All these can be worked out only if proper record keeping is done.

The Committee have considered the system of reporting the expenditure so that the actual expenditure figures can be properly accounted for. The set of proformae devised for reporting such information is given at Appendix 13.2.

With respect to the expenditure on repairs, since the repairs will be carried out at different places—in the field and in the main repair shops, the system of booking of expenditure has to be so tailored that the expenditure involved at various places for repairs of any particular piece of equipment, could be properly sorted out.

To judge the equipment economics properly and to reckon with the history of equipment regarding its performance and cost of maintenance and repairs etc., it is necessary that such accounting of repair costs on spare parts and labour is done in relation to a fleet of machines of the same make and model. It, therefore, becomes necessary that a certain procedure be followed to account for the repair costs—in respect of spare parts and labour charges separately, in relation to individual machines and a group of machines of the same make and model. This can be done only if the expenditure on repairs to equipment are given particular "Code Numbers". Once this is done all indents placed for supply of spare parts, from the users' end, would bear corresponding 'Code Numbers'. Monthly returns and annual returns would then indicate at a glance the cumulative expenditure on repairs of equipment by way of spare parts cost, month after month and at annual intervals, as well as during the life time of the machine or machines in the group.

With a view to channelising the expenditure on repairs costs by way of labour charges the expenditure will similarly be booked to the 'Code Numbers' defined for the piece of equipment or the group of the equipment.

A set of codified numbers developed for the purpose is at Appendix 13.4.

The code numbers as prescribed in the Appendix are of a general nature only. Each user can develop his own code numbers according to his own convenience and maintain the accounts accordingly.

Analysis of the data collected annually could be properly made to determine if the performance has been satisfactory or else certain corrective actions are called for to be taken to improve the performance—either to reduce the breakdowns and increase the time of availability of equipment, whether any costly components/parts have had to be replaced or repaired at intervals shorter than expected, were the breakdowns caused due to lack of preventive maintenance—adjustments etc., are not being done in time, or that the costs of repair could have been partially reduced if timely action was taken to rebuild some of the worn out components/parts.

These aspects have also been dealt with in details in Chapter 10 on "Maintenance Procedures."

13.9 Summary of Observations and Recommendations

Accounting is a means of recording actual expenditure so that proper cost evaluation can be done in respect of product/structure produced in the process of consumption of capital materials, labour, energy etc. The main objective is to economise the expenditure in the process as a whole by controlling the economy in all smaller segments of work involved therein. This could be achieved only if the actual expenditure in all the defined segments, which are susceptible to measurement in terms of value of production or costs, is controlled. The accounts should not, therefore, involve any arbitrary shifting of costs, from items showing cost over-runs to items showing cost under-runs. Arbitrary advance, lump sum distribution of expenses which tend to minimise accounting efforts but distorts current cost accounts by overwriting the cost of items not yet used on works or to reckon the amount of expenditure on notional basis (at pre-determined estimated rates) is to be avoided. Then alone the cost records will not present an apparent balance with the 'Control Estimate' and would instead ensure clear evaluation of the actual costs for purposes of job control and future estimation. This purpose is not fully served by the present accounting system in relation to hourly ownership and operating costs of equipment being used in the Irrigation and Power Sector or P.W.D. accounting system. Hence the present accounting system has to be revised.

Earthmoving machines and other major items of construction plant and equipment consume spare parts for maintenance and repairs valuing 75% to 250% of the cost of the machines in their scheduled life periods. Hence, for control in economy in operations involving use of such equipment, the spare parts costs make one major element to be controlled. A financial control estimate in this respect would essentially involve a clear assessment of the amount or value of spare parts required for the defined service period of the machines to be used on any given job. This again is not generally done, since spare parts are treated as 'Stock Item' under head "Stock Suspense".

Under these circumstances, it is difficult to account for certain contingencies when the consumption of spare parts on given fleets of machines is much in excess of the estimated figures, while simultaneously large inventories are built up involving fairly large investments. Even though such situations can also be attributed to initial estimation of requirements or to the disproportionate rise in the cost of spare parts in relation to a fairly low initial acquisition cost of equipment, it becomes necessary to ensure that the situation as such is not a direct result of laxity in control on purchases.

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To take a more rational view on this aspect from standpoint of accounting, it is necessary to treat the items of spare parts under a distinct sub-head under the main head 'Stock Supense' and to prepare control estimates for regulating their purchase. In addition, accounts be maintained to reflect the value of purchase orders placed during the year, the amount of outstanding payments. The amount of provision and the cumulative expenditure on purchases and the balance of provision etc. etc. A suggested proforma for maintenance of annual accounts in this respect is at Appendix 13.8.

Recommendations

1. Depreciation costs should be accounted for annually based on 'Declining Balance Method of Depreciating'. The life of equipment for depreciation purposes should be fixed in number of years and the rate of depreciation should be selected commensurate with the pattern of work—in one shift, two shifts or three shifts per day.

2. With the exception of depreciation which should be accounted for as an item of ownership cost, all other elements of the cost of the ownership and operating costs of machines should be treated as operating costs or running and maintenance costs.

3. The system of accounting of ownership and operating costs for purposes of booking these costs to the work on which the machines are used should be revised in the manner recommended.

4. Spare parts should be classified under a separate sub-head under 'Stock Suspense' and reserve stock limits defined at the beginning of each financial year. Ex-post-facto sanctions in retrospect should be avoided.

5. Control estimates, fixing upperceilings for provision of the cost of spare parts in the service life of the machines on a given project should be prepared and figures indicated in the project estimates.

6. Accounting should be accepted as a means to serve three purposes, viz. : —

(a) Estimation of costs of future works;

(b) Accounting of the actual cost for purposes of job control and subsequent estimation; and

(c) To provide necessary data and analysis relative to subject of equipment economics, mainly with the purpose of determining the economic life of equipment for replacement etc.

7. Meticulous care should be taken to maintain proper records in relation of costs, consumption of POL and materials and expenditure on labour. Preparation of the record and analysis of costs has to be done by competent hands and in time. Delay in accounting for the cost at different levels, would always give a distorted picture hence promptness is to be ensured in accordance with pre-determined time-table.

8. To simplify the procedure of accounting codification of the items of expenditure in accordance with the modern practice should be developed. If necessary, help can be taken in developing the Code Record Cost Centres from one of the management institute in the country or the Staff College at Hyderabad.

CHAPTER 14

MANAGEMENT, OPERATION AND UTILISATION OF CONSTRUCTION PLANT AND EQUIPMENT—RECOMMENDATIONS FOR

14.1 Management and Organisation—Need For

In the preceding Chapters, the subjects of 'Equipment economics' and the importance of engineering economy related to different facets of work on which such equipment is employed, have been elaborately dealt with. The functional role of management in creating a proper equipment organisation for obtaining optimum utilisation and productivity from the equipment on the job, has also been explained. However, the envisaged pattern of organisation which may facilitate the role of management to be effective in proper direction of control of economy, has not been dealt with so far. This can be better defined after making an integrated evaluation of the basic objectives and principles of management and organisation concerned with equipment and facilities engaged on industrial production. Whether, it is a large-scale manufacturing concern with most of the equipment installed within a covered accommodation; a mine employing mining equipment, earthmoving machines and other installed plants producing iron ore, coal, lignite or other minerals and metals, or large-scale construction projects involving very large fleets of mobile earthmoving machines and other installed construction plant and equipment, the same considerations arise basically to create a suitable organisation to control the industrial economy in each field through proper management of operation and utilisation of the tools of production—the equipment.

In order that recommendations be made in clear terms regarding the pattern of organisation for more efficient management of plant and equipment, it may be necessary to describe briefly the main principles and objectives of a sound organisation.

14.2 Definitions

14.2.1 *Management*

The Management Division of A.S.M.E. has defined 'Management' as the "art and science of preparing, organising and directing human effort applied to control the forces and to utilise the materials of nature for the benefit of man". Sheldon (The Philosophy of Management) states that: "Management proper is the function in industry concerned in the execution of policy, within the limits set up by administration, and the environment of the organisation for the particular objects set before it.'

14.2.2 *Organisation*

Sheldon defines "Organisation" as: "The process of so combining the work, which individuals or groups have to perform with faculties necessary for its execution, that the duties so formed provide the best channels for the efficient, systematic, positive and co-ordinated application of the available effort."

Sheldon also presents one of the best summaries defining these terms in relation to one another:

Organisation is the formation of an effective machine; management of an effective executive; administration of an effective direction. Administration determines the organisation; management uses it. Administration defines the goal; management strives towards it. Organisation is the machine of management in its achievement of the ends determined by administration.

14.3 Organisation

14.3.1 *Principles of Organisation*

The principles of organisation involve clear enunciation of: the objective or the activity, the degree of specialisation involved in functional performance by individuals assigned the responsibility and authority and their relationship with other positions; the Span of Control—the number of persons the man in authority would supervise—specially those whose work is inter-related: the principle of keeping in balance the various units of an organisation; and finally the principle of continuity, as reorganisation is a continuous process depending upon the flexibility of the operations and activities assigned to the organisation.

14.3.2 *Development of Plan of Organisation*

The fundamentals in development of a plan of organisation are: policies, authorities, responsibilities and duties, or activities. The policies set the direction for execution of duties or activities of a predefined nature by persons placed in various positions. Responsibility is accountability for the performance of assigned duties. It is also a moral establishment implying fulfilment of a task, duty or obligation according to orders given or promises made. Authority is commonly delegated only to persons of proven responsibility.

Any plan of organisation may, therefore, be a system of co-ordinated contribution or a system of co-ordinated activities.

Implementation of an Organisational Plan is further based on, operating fundamentals like the development of an adequate system, the establishment of adequate records to implement the system and to use as a basis of control, the laying down of proper operating rules and regulations within the established organisation in keeping with the establishment policies and above all, the exercise of effective leadership.

The express purpose of organisations is to develop co-ordination and morale, yet certain features of organisational building may result in counter-effects.

14.3.3 *Functional Aspects—Specialisation, Responsibility and Authority*

The key note in laying foundations for any organisational building is the establishment of a level and line of authority and the degree of responsibility delegated down the line. This is necessary and essential to frictionless operation of organisational lines of communication. The line of communication must be as direct or short as possible besides it having to be uninterrupted once the activities, duties, responsibilities and authority have been clearly laid down in the line—for officers, supervisors etc.

Accordingly the hope of organisation for management of operation of equipment has to be such as would permit specialisation by desirable functions, and at the same time maintain the integrity of the principle of undivided responsibility and authority throughout the line. Briefly speaking, it may amount to a separation of operating authority and advisory service: The main advantage of creating an organisation of this type would be that it would provide for planned specialisation—bringing expert knowledge to bear upon management and operating problems, more opportunity for advancement of able operators and economy in cost resulting from increased efficiency of operations.

It has, however, to be voluchafed that unnecessary confusion may not arise in consequence of instructions or advice given by the advisory service to individuals in the communication line instead of passing it through operating authority. This could be got over by defining properly the duties and responsibilities of the staff members and the supervisors, so that they can understand each other's view points properly to avoid any friction or misunderstanding due to misinterpretation of the instructions or advice given.

14.3.4 *Allotment of Duties in an Organisation*

The duties or activities are allotted to individuals by giving each person an authority over a certain number of subordinates, or a production centre, or a certain line of product, particular manufacturing plant process or over a series of such processes. or supervision over a particular group of machines or a class of equipment. Each individual has a position description (status) in relation to duties and activities to be performed by him and the nature of responsibility to be discharged by him. As a part of the management, an executive or a supervisor in position is responsible for planning, execution and review of the operations under his jurisdiction; and to feed back the results of the review in order to improve the planning of the next phase of the work. The functions as such may have to be suitably defined in relation to specific positions held by the individuals and the type of work to be supervised or managed by him. But generally speaking, the planning, execution and review part would comprise of the following functions:—

14.3.4.1 *Planning*

(a) *To formulate policy* relative to its function establishment of short and long-term objectives, and to develop programmes to implement these objectives, as well as enforcement of any standard practice instructions spelt out by administration in regard to policies, procedures, forms, organisation etc., relative to the job concerned.

(b) *To forecast requirements*—forecast of requirements of personnel, equipment, materials, finance and other requirements pertinent to the individuals function, preparation of estimates regarding cost of work, schedules of production, time schedules etc. etc.

(c) *To keep abreast with the developments* in the field of management of operations of the technical areas under his supervision and of developments within the overall organisation of which he is a part.

(d) *To establish an organisation* to ensure that each subordinate has a clear-cut responsibility to a single superior, to clearly define the objectives, functions, responsibilities and relationships inherent in the positions under his jurisdiction, to delegate responsibility with commensurate authority to the greatest possible extent to facilitate convenience of operations and in order to utilise effectively the talents and capabilities of those under his jurisdiction; to develop the subordinates suitably so that they are potential successors of the next superiors in proper time and to appoint the required personnel under his immediate jurisdiction, with the approval of his superior.

(e) *To establish internal controls* so as to ensure optimum utilisation of men, machines and materials; to develop procedures, standards, methods, internal controls, budgets and schedules pertinent to his functions and ensure that management controls are governed by a philosophy of "Prevention and good planning" rather than merely by "after-the-fact-control."

14.3.4.2 *Execution*

(a) *To integrate activities* under his jurisdiction, to operate in accordance with the set objectives and policy disseminating same to his subordinates, encouraging suggestions and complaints, directing, motivating, integrating and co-ordinating under his jurisdiction; assigning work to promote a closest possible team work and to ensure appropriate quality and quantity; initiate, maintain and dispose of appropriate records; and protect the assets/equipment under his jurisdiction through proper maintenance etc.

(b) *To achieve cost and delivery objectives* by operating within the approved budget; ensuring that the individuals under his jurisdiction make responsible commitments and promises regarding costs, schedules etc., and that they live up to these commitments; promoting cost consciousness to the utmost, but not sacrificing long-term growth by promoting short-term economies only; and adopting a research minded attitude towards the operations.

(c) *To co-ordinate his activities* with those of other supervisors by working out problems relevant to his position directly with other supervisors affected, but to keep his principal informed in regard to matters for which his superior may be properly held accountable by others or matters which are likely to cause disagreements/controversy or those which require his superiors advice or his coordination with other counterparts of the organisation, or which involve substantial changes in established policies.

To coordinate his activity with those of other departments not under his control and to ensure that operations and services not under his control are brought to bear effectively on his operation.

(d) *To promote sound human relations* keeping in mind the dignity and well-being of the individual employed as a principal factor governing management decisions. To treat subordinates as individuals and to promote feeling of loyalty and a sense of "belonging" on the part of the employees.

To direct the selection, hiring, placing, evaluating, transferring, promoting, disciplining, training, developing and discharging of personnel with emphasis on proper development of employees.

14.3.4.3 *Review*

(a) *To review performance*:—

To review and evaluate continuously the performance of his function and to make recommendations or any action whose need arises from this review.

(b) *To improve performance*:—

To develop a habit for continuous improvement in the job by seeking, accepting and transmitting suggestions and making suitable recommendations; and to coach and advice his subordinates constructively in the performance of their work.

(c) *To report performance*:—

To render a periodic account of progress to his superiors; to ensure that the benefits of the review are fed back into the planning of the next phase of operations.

14.3.5 *Effect of Organisation on Operating Results*

Keeping the above principles, objectives and functions in view, it could be briefly stated that fixing definite tasks and responsibilities in an organisation is a requirement for satisfactory production control. Only by removing all uncertainties and conflicts of responsibility and authority can a smooth running organisation be best set up. Once established and maintained, it must constantly be renewed to operate with a minimum of executive effort and to yield lowest obtainable cost of the end product. In this way, the most can be made of both human and physical resources. The former include the personalities, strong points, training and experience of every member. The latter comprehend the machines, equipment and all other physical agencies of production. Thus organisation affects every activity in industrial operations and is a powerful aid in obtaining economic results.

14.4 Deficiencies in Existing Management Organisations of Equipment Users

As already pointed out in the earlier Chapters, an average user of equipment in the country has failed to ensure reasonable productivity for the costs incurred. Certain questions, therefore, naturally arise in context of the subject term of reference. These are, "Are the organisations exercising then full authority and not abdicating their responsibilities to run their work efficiently?' "Whether procedures for doing the job are, too often, controlled by semi-skilled foremen and craftsmen?" and, "Is management guidance lacking at the level where substantial amounts of money are actually being wasted?"

It may not be readily admitted that there is abdication of responsibilities or lack of management guidance. But we have to consider if there are certain inherent deficiencies in the existing plans of development of organisation for management of construction and mining activities, which may have resulted in lower efficiency in work or persons at certain levels not contributing their skill and effort in relation to work assigned to them; and accordingly, the attributes of abdication of responsibility to run the work efficiently and lack of management guidance get involved by implication. In fact, the control of work by semi-skilled foremen and craftsmen may also be a direct result of the said inherent deficiencies in the organisational set up as functioning at various places.

This may either be a direct consequence of the control of work by semi-skilled Foremen and Craftsmen or the ineffective process of combining the works which the individuals or groups have to perform with faculties necessary for its execution. Apparently, the duties assigned to the groups do not provide the best channels for the efficient, positive and coordinated application of the available effort.

14.4.1 *Responsibility Without Commensurate Authority*

In order to analyse the position clearly, it is necessary to understand the functional relationship of the activities, viz. operation, maintenance and repair of equipment.

Operation is directly related to production. Effective control and management of operation means maximum productivity from machines through optimum utilisation. However, optimum utilisation can be ensured only by proper preventive maintenance and timely repair of equipment. For effective control on the aspect of preventive maintenance, the organisation has to get directly involved in machinery selection for a given item of work, value analysis, care of equipment, cost effectiveness and defects analysis while the normal functions of maintenance engineering, including training, inspection, repairs, methods study etc., are also to be its responsibility. Eventually, therefore, the equipment organisation is fully concerned with:

(a) The degree of skill on part of the operators to operate given items of equipment carefully and efficiently and the training etc., to be given to achieve such efficiency.

(b) Inspection of machinery and the working conditions under which the machine is to work on the job:

(c) The methods of operation adopted—whether any improvements can be introduced for reducing the cycle-time of operation (most of the equipment on production jobs involves repetitive cycles of operation), and to eliminate any delay factors that may be causing longer cycle time and consequent loss in production;

(d) The cost of production—whether it is reasonable or excessive; and

(e) The availability of equipment—whether it could be improved upon by reducing downtime of equipment through expeditious repairs, corrective actions being taken in time for adjustments, or reduction in frequency of repetitive type of defects arising in the machines.

Even though production and operation are synonymous, functionally these get interrelated to the maintenance engineering aspect of work relating to equipment. Either one cannot be isolated from the other. The process of combining the work of operation and servicing of equipment has to be therefore, so evolved that the two functions are managed by one organisation only, under one equipment Manager. This alone can ensure positive and systematic co-ordination of the available effort for operation and utilisation of equipment.

Keeping this in mind, the Committee made some probing questions to the officers managing equipment operation and servicing on the projects visited by them. The questions mainly related to the division of responsibility and authority amongst those separately controlling the operation of equipment and servicing/maintenance/repair of equipment. The idea was to find out as to how smoothly were the two organisation functioning for achieving the main objective of maximum production, least downtime and optimum utilisation of the equipment on the job. At most places, resentment was expressed against the idea of the service organisation reporting to what is named as, operating authority who does not control the majority of the operations that must be performed by the service group. The main area in which lack of such authority became most controversial was the assignment of priorities for the work to be performed by the service organisation. The Production Manager/Engineer was concerned primarily with sustenance of level of production at the optimum while the service Manager was concerned more with the long term benefits that may arise in consequence of timely action to make certain adjustments in various machines in order to avoid breakdowns which may require long term repairs. The service manager felt that the Maintenance Engineering Department—the service organisation, should report to a level that is responsible for the plant/equipment as a whole—Equipment Manager.

14.4.2 *Specialisation—Its Value More Insignificant*

The feelings were expressed that an engineer utilised at a point where maximum advantage is taken of his professional training and experience, would serve for maximum utilisation of his technical background, maintaining a professional approach to upkeep of equipment and the maintenance problems, analytical and long-range approach to problems resulting in breakdowns and hazarding the safety of operations, better understanding of the problems faced by the craftsmen and operators and for developing better skill in the non-technical men in the group managing operation and utilisation of machines. If the functions of professional engineering and crafts supervision are combined, the advantage would be quicker maturity of new technical personnel appointed on the job by intimate association with technical problems, expedition in work because of close communication with experienced persons on top, reduction in supervisory organisational set up, better training in the art of handling men to prepare them technically and for lesser resistance to new ideas since craft heritage is reduced.

The main emphasis was generally laid on placement of inspection and control functions in separate areas in relation to operation and utilisation of equipment. The control function is mainly related to planning, estimation and financial aspects. The problems of inspection find their origin in the primary subjects of maintenance preceding operation and preventive measures necessary as a result of indications manifest from operation.

14.4.3 *Resultant Disharmony*

Briefly speaking, there was evidence of interdivisional conflicts between operating and servicing authority, putting to question the soundness of the principles of creating a fractionless organisation. Division of responsibility and authority, by implication of assignment of duties, involved uncertainities. A clear line of demarcation in the matter of responsibility and authority was not drawn for establishing close relationship and coordination in the activity of maintenance, operation, preventive maintenance and repair of equipment. This certainly was not the congenial atmosphere for the work. This system completely underwrites functional concept of specialisation, responsibility and authority.

14.5 Organisational Set Up for Large Scale Equipment Operation in Different Sectors—A Study

The Committee examined the organisational set up in existence with some of the major users of motorised equipment and plants in the country. These are:—

1. National Mineral Development Corporation—Kiriburu Mines.
2. Irrigation and Power Projects.
3. Rehabilitation & Reclamation Organisation of the Ministry of Labour, Employment & Rehabilitation.
4. The Union Ministry of Transport.
5. National Coal Development Corporation.
6. Neyveli Lignite Corporation.

Specimen organisational charts of some of the organisations are at Appendix 14.1 (as obtained from the equipment users).

14.5.1 *Mining Projects Under N.M.D.C.*

A study of the organisation chart of the Kiriburu Project of N.M.D.C. will indicate that the Production Manager is directly responsible to the General Manager (Shop Manager of the Unit) as under his charge. The Service Department and the Production Department.

The Service Department headed by a Service Manager is responsible for maintenance of mining equipment, motorised equipment, automobiles and running and maintenance of the Workshops.

The operation and maintenance of installed crushing, screening, conveying and loading plant is the responsibility of the Deputy Production Manager (Plant).

There is no indication in the Chart as to who manages the operation of motorised equipment used in the mines. On enquiries made during the visit of the Committee to the project it was understood that the Production Manager directly controls the operation of motorised equipment in the mines with the help of some junior officers—General Foreman (Mining) and others of lower rank. Both the General Manager and Production Manager are Mining Engineers and the Service Manager and Deputy Production Manager (Plant) are Mechanical Engineers.

The service department in this case does not perform the functions of operations research or time and methods studies, which generally help in improving production by eliminating delay factors in the production cycles. Moreover, the motivation for work on part of the Service Department for activities other than the normal maintenance work arises only from reports received from the operating authority in charge of production work. Consequently, the service organisation functions more in the manner of 'after-the-fact-control.'

The Committee also visited the Bailadila Iron Ore Project. In this case the Service Manager was charged with the responsibility of both maintenance and operation of motorised equipment in the mines while the operation and maintenance of installed crushing, screening, conveying and loading plant was the responsibility of the Plant Manager. Both of these officers were under the control of a Deputy General Manager, who was not in position at that time.

14.5.2 *Irrigation and Power Projects*

On the Irrigation and Power Projects, the charge for construction works is assigned to individual construction Circles, who collectively work under a Chief Engineer/General Manager of the Project. The equipment and the repair shop are under the charge of a Superintending Engineer (Mechanical)/Executive Engineer (Mechanical) depending upon the size and value of the fleet of equipment in use.

The Superintending Engineer (Mech.)/Executive Engineer (Mech.) some times controls the entire process of work on equipment starting from the operation of the machines, maintenance, repairs etc. Yet at other places, the operation of equipment is assigned to a Construction Circle headed by a Civil Engineer. Executive Engineers (Mech.) are placed under the control of the Construction Circle and they look after the operation, field maintenance and field repairs of equipment. Major repairs of equipment whether in the field or in the workshops, are attended to by the officers/staff under charge of the Superintending Engineer (Mech.) looking after the repair shops.

Sometimes, Civil Engineers' are in charge of operation in the Construction Circle and the work of maintenance, repair and overhaul is left to an Executive Engineer (Mech.) in charge of the repair shops.

Different patterns of organisation, therefore, exist on Irrigation and Power Projects in individual States.

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14.5.3 *Rehabilitation Reclamation Organisation*

The Rehabilitation Reclamation Organisation under the Ministry of Labour, Employment and Rehabilitation, is headed by a Chief Engineer (Mech.). A number of operating units are under his command in different locations within the country, including Andaman Islands. He has under his charge unit officers of the rank of Executive Engineers (Mech.), who command the operations with 20 to 25 pieces of equipment in each unit.

14.5.4 *Union Ministry of Transport—Directorate General of Roads*

The Chief Engineer (Mech.), Directorate General of Roads, Union Ministry of Transport, has advised the Committee to refer to the Report of the Road Building Machinery Committee (1970), regarding details of the organisation for control of machinery. Following is an extract from Chapter IV, paras 4.2, 4.3.1 and 4.3.2:—

"4.2 With a view to ensure that the machinery given to the States for execution of the Central or Centrally sponsored works is put to proper use to guide the States P.W.D. officers on the proper running and upkeep of the machinery, one Executive Engineer (Mechanical) was posted in August, 1962 who was made responsible for the running, maintenance and repairs of the road making machinery and training of the staff to run the machines, with headquarters at Delhi. He was later on shifted to the field in May, 1963 The Mechanical branch of the Ministry was gradually expanded and two regional Superintending Engineers (Mechanical) were posted to work in the field, one in Bihar and another in West Bengal, in January, 1967. They were assisted by 4 Executive Engineers (Mechanical) and 3 Assistant Executive Engineers (Mechanical). The headquarter of the Regional Superintending Engineer (Mechanical) at West Bengal was, however, shifted to Assam later on. The Superintending Engineer in Bihar looks after the machinery in U.P., and Bihar. The other Regional Superintending Engineer looks after the machinery in West Bengal and Assam. The main works in progress in the four States is the Lateral Road Project. In Assam, work on emergency roads is also in progress. I.D.A. works had been virtually completed when these Superintending Engineers were posted.

4.3.1 The duties assigned to the Regional Suptg. Engineers were as under (in the Ministry's circular No. LR-8(2)/67, dated 6th September, 1967 and No. RM-30(2)/67, dated 26th October, 1967).

(i) To examine all requests made by the contractors or the State Governments for the release of foreign exchange for import of machinery or equipment to be imported in connection with the execution of road and bridge works.

(ii) To supervise generally the distribution, use and maintenance and mechanical equipment.

  (a) To ensure proper maintenance and repairs of all the machinery purchased out of central funds for all the road projects;

(b) to ensure proper maintenance of the Log. Books, History Sheets, Registers, etc,

(c) to send to this Ministry requisite reports regularly by the due dates in the proforma prescribed by the Ministry from time to time for the purpose.

4.3.2 Detailed discussions were held with the Regional S.Es. on how far they were able to perform the functions assigned to them. It transpired from these discussions that they were unable to discharge these functions to the extent required of them for various reasons such as shortage of staff, reluctance on the part of the State P.W.D. Officers to furnish particulars required on the running of the machinery etc., and also in some cases, lack of adequate response on the part of the State P.W.D. Officers, to the advice tendered by the S.Es. and other staff. Since no powers were given to the regional S.Es., they are experiencing difficulties in fulfilling their duties entrusted to them. They should be vested with sufficient powers to prevent gross misuse of the machinery. They should also take timely steps to advise the State P.W.D. officers in advance booking of spare parts. The Committee is making its recommendations separately (see para 4.9.19) on the steps desirable to be taken."

In the same Chapter, the following recommendations have also been made:

"(1) In future projects, forward planning and programming of the use of machinery should get top most consideration.

(2) Considering the fact that the Mechanical branch in the Ministry has the responsibility for the equipment purchased by the Central Government, a suitable reorganisation and strengthening of this also appears to be necessary to ensure best results.

(3) The State P.W.Ds. may be encouraged to strengthen their mechanical set up on the lines of the Central Mechanical Units established in various States for the Irrigation and Power Sector. Where this is not feasible, the Regional Superintending Engineers (Mechanical) of the Ministry in these States, may be given adequate mechanical establishment for this purpose."

In view of the peculiar circumstances where the equipment is owned by the Central Government and is used mainly by the State P.W.D., with the officers of the Central Government having rather limited authority in management of operation of equipment, evidently measures for improvement in utilisation of equipment cannot be effectively implemented. To overcome this situation, the Ministry of Transport have now taken a view on the recommendations made in the RBMC Report and decided in favour of selective ownership of sophisticated and costly equipment by the Ministry of Transport. Rest of the equipment which are of general and minor nature, will be owned and operated by the State Governments.

14.5.5 *National Coal Development Corporation*

National Coal Development Corporation which is operating now 15 Open-cast Mines producing coal ranging from 0.4 million tonnes to 1.5 million tonnes per annum, has the following organisation.

A Chief Engineer (Excavation) at Headquarters is in overall charge of equipment planning and staffing functions in 15 Open Cast Mines in addition to two Central Workshops, one at Korba and the other at Barkakana. Two to three Mines or more, as may be contiguous, are grouped as one area and at the area level, there is a Dy. Chief Engineer/Superintending Engineer in charge of the overall charge of the equipment in the area. At the unit level, i.e. Open Cast Mine level, there is a Senior Executive Engineer/Executive Engineer, assisted by a team of Assistant Engineers/General Foremen. The Senior Executive Engineer/Executive Engineer is in charge of the maintenance of operation of heavy earthmoving equipment working in the Open Cast Mines, including the unit workshops set up to attend to the repairs of the equipment.

The deployment of the machines is accordingly made to achieve the programmes as planned and scheduled for production of coal and removal of over-burden.

The Chief Engineer formulates the policy of equipment selection, procurement of spare parts, service organisation, servicing equipment, and also the servicing standards and records to be maintained. He is the Staff Officer to the Director Technical/Managing Director, in respect of heavy earthmoving equipment and the workshops. He is also in charge of indigenisation of spares, standardisation and planning and one of the Members of the Planning Committee which formulates project reports for Open Cast Mines.

However, since it is peculiar to the coal mining industry that a considerable amount of overburden has to be removed in order to lay bare the coal and this involves considerable expenditure prior to the actual production of coal and the economy in the Open Cast Mine directly depends on the judicious removal of over-burden to the desired extent. There is a programme to formulate a separate Quarries Department, whose function would be to coordinate all the activities in the Open Cast Mines.

14.5.6 *Neyveli Lignite Corporation*

Neyveli Lignite Corporation is operating open-cast mines producing lignite to the extent of 3.5 million tons per annum. As of present the Corporation has construction plant and equipment worth 26 million.

In the organisation of the Corporation there is a Chief Engineer (Mechanical) whose functions are to look after the maintenance and repairs of equipment. The equipment operation is not under the control of the Chief Engineer (Mechanical). The Operation and production are looked after by the Superintending Mines.

14.6 **Equipment Organisation—the Proposed Pattern**

14.6.1 *Responsibility of Equipment Manager*

All the work incidental to management of equipment, viz., plant planning, selection of equipment, record keeping, care-taking of equipment, accounting of costs for operation, maintenance and repair of equipment, training of personnel, inventory control of spare parts, time and method studies, cost effectiveness and defect analysis, guidance to supervisory staff down the line, should be the responsibility of the Equipment Manager. He should be delegated appropriate authority commensurate with responsibility to manage all these incidental items of work for efficient control of equipment operation and utilisation, and minimum cost of production.

Taking a summary view of all the observations and conclusions of the Committee, in relation to different aspects of the work related to construction plant and equipment, as discussed in earlier Chapters, the Committee is seized of the need for improvement in the pattern of organisation managing equipment operation and utilisation. Their recommendations in this regard are spelt out in details in the concluding portion of this Chapter. However, some specific observations relating to suggestions for change in the present pattern of organisation for equipment management are dealt with below.

14.6.2 *Recommendations of Earlier CPMC*

The most important consideration is that of specialisation. Plant Engineers and Equipment Manager should be only those persons who are professionals/specialists in this field. Due amount of authority to be delegated to him, commensurate with responsibility of the position he would hold as Equipment Manager, would necessitate proper assignment of a "Position" in the organisation. In this context, it would be appropriate to quote an extract from the Report of the first Construction Plant and Machinery Committee. Para 3.19 of the Report states as follows:—

"PROPER PLACEMENT OF AUTHORITY.

3.19. Regarding the mechanised organisation, we felt that inadequate attention is paid to a proper set-up in most of our projects and that the importance of a high standard of control on machines is not appreciated. Over half the expenditure on even a modestly mechanised project is through machines. The machines and their supervising staff are placed as tools in the hands of Civil Engineering Officers who do not have adequate knowledge of the technique and performance of equipment. We do not advocate independent charge of mechanical engineer, since this would create divided responsibility but we do believe that the sphere of responsibility of the entire mechanised field should be set at as high a level as possible in the administration of a project. We feel that the Nangal and Hirakud Organisations have scope of improvement in this direction. Even on small projects such as Lower Bhawani or Gangapur, the bifurcation of the mechanical engineering is done starwise—in that many officers are independently operating under the Executive Engineer. An integration of all of them under a Plant Engineer with unitary control would be an improvement."

The recommendations as above of the previous Committee, get further strength from the increased intensity of mechanisation, involvement of more sophisticated equipment and complexity of the present day construction jobs. Recommendations made about 20 years ago have not only to be revalidated but a more effective direction has to be set for attaining the objects of managing the functions of planning, selection, application, operation, maintenance, repair and utilisation of equipment on major construction/production jobs—specially those involving worth Rs. 50 million and above. Officers of the rank of Additional Chief Engineer and Chief Engineer would satisfactorily meet the requirements of: "—as high a level as possible in the administration of a project.", as specified in the above recommendation. The corresponding administrative control on such major works is under officers of the rank of Chief Engineer/Project Manager/General Manager. Additional Chief Engineers (Mechanical)/Chief Engineers (Mechanical) would properly fit in for unitary control.

14.6.3 *Value of Equipment—a Yardstick for the Size of Equipment Organisation.*

It was also reported by that Committee in para 3.18 of the Report that although a normal divisional charge in P.W.D. should be able to handle project works through contracts to the extent of about Rs. 40 lakhs per year, mechanised departmental work should be limited to about Rs. 25 lakhs. The Committee had expressed the opinion that if more is attempted, it will result in inadequate control and higher costs causing overall uneconomical performance. That Committee had further indicated that the strength of such a division should be about 1.5 times the normally accepted standards for divisions.

This Committee concurs fully with the thinking on part of the previous Committee regarding value of work to be assigned to a division on annual basis for mechanised departmental work. Accordingly, therefore, if work worth Rs. 25 lakhs is to be done departmentally with machines, this would involve equipment worth Rs. 70 to Rs. 75 lakhs approximately (even Rs. 60 lakhs worth of equipment could do work worth Rs. 25 lakhs if three shifts operations are involved). Hence, for purposes of scaling of an organisation for management of operation and utilisation of equipment, the value of equipment, to be placed under charge of an officer, may be taken as a yardstick. It is suggested that for equipment worth Rs. 75 lakhs to Rs. 100 lakhs, an officer of the rank of Executive Engineer should be responsible therefor.

On the same analogy, wherever equipment worth Rs. 25 million to Rs. 40 million is involved, a Superintending Engineer should be in charge of its management.

For mechanised operations with equipment valued at Rs. 50 million to Rs. 70 million, an officer of the rank of an Additional Chief Engineer may be in charge.

For equipment worth above Rs. 70 million, the charge may be assigned to an officer of the rank of Chief Engineer (Mech.) (who may be designated as Equipment Manager).

14.6.4 *Functional Distribution of Work.*

While the yardsticks as above provide the norms for determining the size of the organisation that should be created for equipment management, functional distribution of duties amongst officers of the organisation could be best determined in relation to the work spread. By this, the reference is to a number of works spread over a wide area/expanse involving small units of equipment at locations wide apart from each other. The example of this is found on canals excavation, land reclamation etc. All these small units of work form a part of a much bigger work or a project. Each one of these small units may use a limited amount of equipment. Equipment worth Rs. 7.5 million to Rs. 10 million could be put under a Divisional Officer. This is the pattern followed by the Rehabilitation Reclamation Organisation under the Ministry of Labour, Employment and Rehabilitation and on the Rajasthan Canal Project. 2 or 3 units of tractor-drawn scrapers and other smaller machines, like compaction tractors and rollers, a grader or in the alternative a number of draglines spread over 10 to 15 miles length of the canals numbering 25 to 30 pieces of machines (with 8 to 10 machines in each smaller unit), are put under the charge of a Divisional Officer.

Opposed to this, large fleets of equipment may be concentrated in a smaller area on a major project. These may include excavators, dumpers, tractor-dozers, tractor-rippers, graders, compaction equipment, concrete handling equipment—cranes, locomotives, transit mixers, platform trollies for carrying concrete buckets, rock drilling and quarrying equipment, mixing equipment and other miscellaneous items. The examples of such large scale equipment operations are found in Irrigation and Power Projects, Mining works or Port Development works etc.

In such cases, it is customary and essential to provide facilities for repair and maintenance of equipment, procurement of materials and spare parts in a centralised manner. Such centralisation is considered essential from the standpoint of specialisation and economy in investment costs. It is also possible to reduce the manpower to the minimum for performing certain functions through one agency instead of the same being performed by a host of officers individually in relation to few machines under each person's charge. By this, the reference is to maintenance of equipment, repair facilities, procurement of maintenance materials, operating supplies etc. etc.

To introduce effective control on the cost of work on the project as a whole or for the entire fleet of equipment on the project, even the cost valuation is a centralised subject in a Cost Cell.

The operation, maintenance, preventive maintenance and inspection, repairs are also sub-divided itemwise and form separate subjects for assignment of duties to individual officers. The type of organisation that may be created for equipment management in this manner is illustrated in the following example.

For construction of an earth dam where Rs. 50-60 million worth of equipment—about 150 numbers, is to be put to use, the number of Divisions that may be established to manage the operation and utilisation of equipment on the job will be six or seven, according to the defined yardstick. The operation and field maintenance control may be assigned to '3' Divisions by allocating 50 machines to each one of the three Division Officer. This Four Divisional Officer may be exclusively made responsible for workshop repairs to the total fleet of equipment. The workshops would, in addition, have facilities for other incidental items of work relating to upkeep and repairs of machines and other miscellaneous jobs of Structural and 'General Repairs and Fitting' nature to be carried out in relation to other activities of the project. The Fifth Divisional Officer will be assigned the work relating to procurement of spare parts, maintenance materials, operating supplies and procurement action in respect of any other items required in the workshops and for the machines etc. He will also be responsible for inventory control of spare parts. The Sixth Divisional Officer may be assigned the work of inspection and preventive maintenance of equipment, keeping history record of performance of machines and scaling of consumption of spare parts etc. The Seventh Divisional Officer will be assigned the responsibility for Planning of work with equipment, coordination with all other Divisional Officers regarding preparation and finalisation of annual estimates, incentive schemes, establishment matters, work improvement methods and the cost control cell.

The above example is illustrative in nature, though specifically related to a construction job. Such sub-division of work can be similarly done even in case of equipment used in mining work. Instead of designating the officers in charge as Divisional Officers, suitable designations, as may fit into the individual organisations, may be used.

A suggested Organisational Chart showing distribution of work amongst various officers on a project using large fleets of equipment—Rs. 100 million and above, is given at Appendix 14.2.

Similar position would apply to production in mines where in fact almost 80% of the cost of production is accounted for in terms of activities and operations incidental to utilisation of equipment. Of this, 50 to 60% of the total value of production would be directly attributable to the plant and equipment operations alone. The efficiency in management of these operations would be directly proportional to the control exercised by competent Managers of equipment. Here again the same yardsticks for determining the scale of the organisation in relation to the value of equipment as suggested above, may apply.

It is suggested that the mobile equipment may be under the charge of an Equipment Manager and the installed plant may be under charge of a Plant Manager, while both of them may be responsible to the 'Deputy General Manager, Plant & Machinery'. The suggested designation are only description for purposes of classification.

14.7 Training of Executives & Supervisors

Another important functional objective is to promote sound human relations by directing the selection, hiring, placing, evaluating, training etc., of personnel with proper development of employees.

In order to fulfil these objectives effectively, it is only necessary that the entire lot of personnel supervising such operations incidental to equipment and the craftsmen actually doing the work with the machines should be suitably trained. The matter regarding training of operators and mechanics is a separate subject, which has been dealt with already in Chapter 7. In so far as the training of Supervisors and Executives is concerned, the main objectives of such training would be as follows:—

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14.7.1 *Training of Executive Staff—Assistant Engineers, Executive Engineers and Above*

The training of the executives should be such as to make them clearly understand the functions of Planning, execution and review in relation to specific position held by them. The following points may further elaborate the objectives in view:

1. Effective implementation of the programme relating to training of operators & mechanics.
2. Equipment management and control.
3. Selective choice of equipment.
4. Record keeping of equipment for study of equipment economics, scale of consumption of materials—operating supplies and spare parts etc.
5. Care taking of equipment from standpoint of operation safety, maintenance, preventive maintenance, facilities for servicing, repairs, transportation, cleanliness.
6. Human Relations.
7. Plant Planning for economy in end cost of work done by the machines through selective choice of available items of equipment in different combinations.
8. Liaison/Co-ordination with the operating, servicing maintenance and repair Divisions/Establishments.
9. Programming of work.
10. Cost Accounting and Cost Control.
11. Financial Budgetting and control.
12. Incentive Schemes for better production.
13. Effective utilisation of equipment for optimum production and measures necessary to accomplish this.
14. Requisitioning of maintenance, servicing and repair supplies after proper estimation and scaling of requirements, consistent with programme of work and future requirements and based on actual experience.
15. Training of personnel under formalised training schemes and "In-service-Training".
16. Disposal/Rehabilitation of surplus equipment.

14.7.2 *Training of Supervisory Staff, Including Chargemen, Foremen and Supervisor/Overseer*

In respect of training of Foremen and Chargemen and Supervisor/Overseer, the objectives would be as follows:—

1. Comprehensive understanding of objectives relating to Operator training and Mechanics' training.
2. Creating proper environments for work with equipment.
3. Facilities required for satisfactory servicing, maintenance and repair of machines.
4. Selection of lubricants and greases etc. with a view to standardisation and simplification of the number of brands and grades of oils and greases to be used.

5. Care taking of equipment from standpoint of operation safety, maintenance, preventive maintenance, facilities for servicing, repairs, transportation, cleanliness.
6. Relations with operating, servicing, maintenance and repair staff.
7. Creation of proper records relating to expense account in operation, servicing, maintenance and repair of machines.
8. Creation of records indicating history of performance of machines with analysis of nature of breakdowns suffered, their incidence and frequency, causes contributing to such breakdowns and faults, extent of wear and tear suffered by components over defined periods, inspections carried out, modifications made to equipment etc., etc.
9. Estimation of cost of work.
10. Estimation of total requirement of operating and repair parts supplies for running, maintenance and repairs of the machines on monthly basis and on annual basis.
11. Forecast of requirements of these supplies for future commensurate with programme of work and lead time for procurement.
12. Measuring and rating the skill and efficiency of the staff—Operators, Mechanics etc.
13. Preparation of specifications, standards for repairs, disassembly and reassembly, maintenance and servicing of the machines etc., for guidance of the workmen.

14.7.3 *Training Scheme—A Proposal*

The main consideration leading to the training of supervisors and executive staff is that a supervisor, during the hustle and bustle of the normal routine of the activities cannot adjust himself to the needs of the non-routine problems, specially when certain decisions have to be taken relative to problematic conditions. Such conditions arise in consequence of ever-increasing complexity of technology and sophisticated nature of equipment introduced on different jobs from time to time. Under such conditions the Supervisor should also be able to train the craftsmen and other people employed on the job under him so that they can handle the work skilfully and efficiently.

His main area of training is related to his job knowledge and experience. He should also know precisely and clearly the basic work standards and work standard measurements before he can exercise proper control on the operations in a given item of work. It has not to be an attitude of, "The job has to get done"; the "How" and "Why" of a job are more important and it is in this area that the supervisor can control the operations.

The Committee have considered this subject of supervisors' and executives' training in relation to construction industry—Irrigation and Power Projects. Details of the suggested training scheme are given in Appendix 14.4.

The scheme for training of supervisors etc. would also provide an opportunity for refresher courses being conducted for those who already have certain skill of proficiency in the profession. The object of keeping abreast with the latest serve for them by this training scheme.

14.7.4 *Technical Education to Cover Subjects Related to Construction Method and Equipment*

The Committee were sounded by various departments/projects that best talent in different disciplines of engineering cannot be always attracted for enrolment in suitable positions either in management of equipment, or in construction work. The Committee, therefore, have also examined the basic need of improvements to be made in the system of technical education by covering certain subjects relative to equipment economics, methods and techniques of construction, Selection of equipment for given job application, Planning of equipment for better production, etc. Reference was made to 28 numbers Head of Technical Institutes and Universities, where the Civil Engineering courses and Mechanical Engineering courses are administered. A synopsis of points/comments made by the institutions/universities, is given at Appendix 14.5.

A study of the information given in these Appendices would lead to the conclusion that the need for these subjects being introduced in the universities/institutes, where these are not being taught at the present time, is fully appreciated. There is need for further effort to enhance the scope of the study in these fields on part of those taking technical education. This matter would have to be pursued further through the appropriate section of the Ministry of Education, so that some degree of uniformity can be introduced in covering these subjects in all technical institutions which produce Graduate Engineers in different disciplines of Engineering. This would largely help in better management of equipment operation and utilisation by Engineer-Managers.

14.8 Other Important Considerations for Attaining High Efficiency in Management

14.8.1 *Design and Layout of Construction Plant Facilities*

The general concept as to how the work is to be performed would evolve from studies made in the project estimate. These would be further revised in the process of making further analysis at the time of commencement of the work when initiation of action for procurement of equipment takes place.

The amount of effort to be expended in plant lay-out and design will vary widely, depending upon the complexity and character of the work to be performed. Careful consideration of this subject at the time of commencement of the job is, however, indispensable to the establishment of proper construction procedures and the ultimate economy of the construction operations.

For jobs of relative simplicity, plant design and layout can be easily handled. For complex and diversified construction problems, however, this would have to be finalised after taking a second opinion from a competent authority—according to the present system in consultation with the Central Water and Power Commission. It might also become necessary to employ professionals for this purpose on the job, so that the work can be properly organised. Plant Engineers, or Equipment Managers could be specially appointed wherever major operations are involved with plant and equipment.

Design of nonstandard plant structures involving heavy loadings must be considered with the greatest of care to ensure safety at the site of work and the continuity of operations. Such plant facilities as cable-way towers, whirley crane trestles, screening towers etc., design for special adaptation to a particular site should be thoroughly checked for structural soundness of members and connections after completion of the original designs. In this case, specially, a second opinion by a competent authority is most essentially called for.

Provision should be made for the incorporation in the construction plant of all safety devices that can be reasonably justified. Guidance in this connection should come from accepted practice.

A comprehensive and complete record is to be compiled of all plant lay out and design data. The same is to be preserved in relevant job files, through out the period of construction activities and, later, condensed and incorporated in the final job report. Plant drawings should be made on standard size sheets, properly titled, dated and numbered, to facilitate reference. Design criteria and structural design calculations shall be recorded and preserved. The records of size, weights, quantity and actual cost of plant and its components, shall be made in sufficient detail to permit its analysis according to sub-divisions of work set forth in the cost control estimates.

During the life of the job, copies of plant drawings, plus detailed information as might be found desirable to illustrate major construction operations and substantiate plant items, shall be recorded and preserved in the relevant job files.

14.8.2 *Time and Methods Studies*

Due consideration must be given to the study of methods for the performance of construction operations with plant and equipment and the time required for such performance. This matter is some times over-done but more frequently disregarded. It is an important function, because it has to do with basis elements of cost of the completed construction product. The extent to which the time and methods studies should be employed is, of necessity, a matter of opinion in light of the possible results it could produce.

The basic concept of plant and its general functions is always determined in advance and incorporated in the budget control estimates. Thus, the general pattern of performance is already established to a large extent. It is, of course, necessary to check out the performance of various plant components or a connected controlling operation for efficiency and adaptability. For a time and methods study to be of value, it must be applied to highly repetitive operations where corrective measures indicated thereby will have a long time to operate in the interests of economy. It, however, has an intangible advantage of considerable force from a psychological view point—that of promoting greater individual productivity of the job personnel as and when they come to the realisation that their performance is being recorded and measured competitively against counter-parts on other shifts or on other jobs. It promotes personal pride in accomplishment, team work within the individual construction crews, individual interest in the work and alertness to better ways of producing the end result.

If the time and methods study is to be of some use, the cost study data shall be set down, in a form directly comparable to that provided in the original estimate, for ease of analysis. The progress reports shall serve the purpose of examining or showing how specific cost data obtained compares to similar values provided in the estimates or produced by other crews.

Time studies alone or production studies alone are often of material value without attempting to evaluate cost per each such study, since time and production are the basic elements of costs. Favourable or unfavourable results pointed out by the data obtained, will be of value to the management, in localising difficulties that might be created by changing personnel or method.

Operations suceptible to time, production or methods study are listed below as a partial guide:—

1. Detailed breakdown of trip cycles for cable-ways, cranes, batching and mixing plant, concrete transfer cars, concrete whole trucks or trains, power shovels, drag-lines, scraper equipment, push tractors, dump trucks, spreading equipment on embankments, rollers, round cycles in tunnel and shafts etc.
2. Production studies are often advisable for rock drill advance, power shovel or dragline loading (volumes measured by cross-sections or computed quantities, number of truck loads etc.), hydraulic sluicing, blasting results etc., etc.
3. Efficiency of equipment should be checked to determine if it is meeting manufacturers' rated capacities, or accomplishing the purpose for which it is provided. Observation should be made specifically with respect to pumps, crushers, aggregates, screens, rod mills, sand classifiers, conveyors etc.

14.8.3 *Accummulation of Performance Data*

The extent of this activity will generally depend upon the kind and complexity of work involved on a project and the possible usefulness of data compiled as related to the expense involved in doing so. It is, however, the responsibility of the engineer to accumulate, record and preserve performance data that will accurately measure the amount of work accomplished by and efficiency of specific operations of equipment.

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The source of this data shall be the time cards, equipment reports, field observations, special studies etc., on which the amount of work accomplished is recorded or developed. Complete cooperation with the work forces must be maintained for its effectiveness. Coincise and continuing records are to be maintained for major operations forming the basis for periodical reports to management at all levels. More detailed reports and summaries of performance data shall be compiled as necessary with respect to specific equipment etc., required for measuring cost that can be used in the preparation of proposals for future work.

14.8.4 *Classification of Construction Cost Data*

The P.W.D. Accounting system, as adopted by the Irrigation and Power Projects, or other departments where mechanised construction work is involved, is very cumbersome. Hence, it becomes necessary for special accounting manuals to be compiled and published by individual departments/projects were large scale use of construction plant and equipment is made. The Accounting Manual clearly spells out the heads in which the important elements of costs have to be sub-divided for cost accounting purposes. The P.W.D. Accounting Code and the project accounting manual can be suitably coordinated in developing desirable cost separations for estimating and cost accounting purposes. Budget control estimates can be made on the resultant pattern of cost accounting system so developed, so that these are in conformity with the standard practice instructions that may be introduced. These would set the pattern for cost accounting and reporting to be followed.

However, the engineer in charge of equipment who shall be generally familiar with the requirements of equipment, the plan of operations etc. etc., shall have to be consulted for finalising the accounting system for convenience of accounting and maintenance of records. If this is properly done, it will provide the means of furnishing a clear summary of the information by the Accounting Department for prompt reporting.

It is to be noted that arbitrary advance lump-sum distribution of expenditure, which tend to minimise accounting efforts but distort current cost accounts by over writing the cost of items not yet used in the works, is to be avoided.

It is also important to mention that consideration be given to deferring of all or part of the expenditures entering into facilities which will serve future construction operations. The plant facilities would fall under this general category for which special provisions are made.

The cost records as kept, are intended to reflect actual costs for the purposes of job control and future estimating. There is to be no arbitrary shifting of costs from items showing excess over estimated expenditure to items showing expenditure lesser than the estimated cost, if the objective is to present apparent balance with the control estimates.

14.8.5 *Reporting Cost and Progress Information*

Reference to detailed reports with regard to progress and costs in relation to maintenance, operation, repair and overhaul of equipment, has already been made in various Chapters,—specially in Chapters 8, 10 and 13. Such reports are of daily, weekly, or monthly periods. The primary purpose to be served by such reports is to accurately convey the current status of the performance of the equipment and of the job to the management at all levels, so that it is in a position to determine the probable areas of existing job problems and take prompt remedial actions as necessary. Such reports are necessary also, to permit engineering analysis of the plant and equipment and job operations, as may be required to advise management on such matters. These reports also make the record for reference for estimation of costs on future works of similar nature.

The responsibility for such progress reporting and record compilation is that of the Plant Engineer or the Equipment Manager. Preparation of the reports/records has to be a joint effort of the engineer and the cost accounts cell or the accounting organisation in order to set forth a true and accurate picture of the costs. To be of value, cost and progress reports must be prepared and transmitted promptly. Daily reports, where required, must be available to the management the day following the performing the work. Weekly reports, where required, must be available before the middle of the week following that during which the work was performed. The monthly reports have generally to await closing of the books after the conclusion of the month's work to determine costs as recorded. But these should be available to the management not later than by 15th of the month following the close of the month being reported.

Distribution of reports amongst various offices will be according to the standard practice instruction laid down by the administration/management.

14.8.6 *Production Records*

Production records shall be kept for the major items of equipment and plant used on the work to measure accomplishment and efficiency for purposes of job control and for estimating future work. Like items of equipment might well be grouped for this purpose unless there is an occasion to check on specific operators or supervisory personnel.

The choice of which production units to make the subject of separate production records rests with the management. However, the Plant Engineer has to establish at the outset—at the inception of the work, the information that would be desired along these lines with due consideration to the future value of such record.

To be of any future value, production records must be related to the time of use, such as cubic yards per year, tons per day, linear feet per hour etc. In addition, the conditions under which the production is accomplished should be clearly stated so that this can be readily understood for normal reference.

It is normally advisable to prepare production records for the following units of equipment: —

1. Power shovels and draglines.
2. Dump trucks.
3. Scraper equipment.
4. Large rock drills.
5. Aggregate production plants.
6. Concrete batching and mixing plant.
7. Concrete placing cranes.
8. Cable-ways.
9. Belt conveyors/loaders.
10. Tractors and bulldozers on production work or compaction work.
11. Other items that have a major influence on the cost of the work.

14.8.7 *Job Completion Reports*

In relation to plant and equipment. it would also be necessary to include the following items in the job completion reports: —

1. Analysis of general plant.
2. Report of specific plant.
3. Equipment costs report.
4. Plant operations report.
5. Production records report.

Such reports would help in evaluating norms and guid-lines for subsequent jobs to be undertaken.

14.8.8 *Maintenance Materials Management*

Scheduling and planning make two distinct functional divisions of management. For scheduling, resources provisioning is an important element for consideration. Planning for the material resources to the point of ensuring timely availability of materials on the job, is materials management.

Production working involving large scale use of equipment involves consumption of material. Equipment used on construction/production jobs needs raw materials, spare parts, consumables, energy and labour. Except the labour part, the other requirements cover consumable items. The cost of these consumptions is sometimes as high as 80% of the cost of the work done. It is, therefore, necessary to organise proper control in the matter of provision and distribution of the materials.

Materials management covers three distinct functions, namely, (1) procurement, (2) inventory control, and (3) distribution. For economy in production, it is necessary that minimum investments are made in procurement of materials, the size of the inventory and the arrangements of distribution at the consumption points.

For an efficient process of procurement, forecast of requirements, market research, expedition in processing of enquiries and requisitions, the procurement method and consumption control are the few important items for control in economy.

The forecast of requirements and consumption control are closely related functions. The consumption indicates the pattern for framing a forecast of maintenance requirements based on past experience in respect of such items as would also be used in future irrespective of the age of the machine. There are certain items which are required in stages as the age of the equipment progresses in use. In order to forecast the requirements of this class of maintenance items, anyone undertaking to do this work must clearly understand the plant and equipment for which the materials are required. The machine can be divided into systems/assemblies/components and parts. Listing of such important items can be done with reference to the spare parts catalogues relative

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to plant and equipment and a clear analysis prepared in terms of time intervals when individual items would be required for the machines—for their maintenance, repairs etc. Such analysis, prepared initially for new equipment provided on the works will be as correct as the judgement of the individual making it. However, in course of time, corrections can be made; and these corrected statements would serve to be the main guide for subsequent or future assessment of requirements for similar or identical machines that may be added on the job.

Inventory control also plays an important part in framing a correct estimate of the forecast of requirements. A scientific approach in determining the limits for stocking the selected items of maintenance parts etc., with due regard to the lead time in procurement. The scale of consumption in the past or anticipated for the future would enable the minimum requirements of maintenance supplies to be included in the forecast of requirements.

Distribution of the items received after procurement has also to be meticulously planned and controlled. The controlling authority at the users end should not unnecessarily create reserve of the maintenance parts, materials etc., considering all such items as insurance supplies. Classification of insurance items should be clearly done while identifying the pattern of consumption for forecast of requirement. Such insurance supplies must be held in central stock at one point and unnecessary amassing of similar parts at different locations or the points of consumption should not be allowed to occur.

The degree of success that can be attained in maintenance materials management is greatly influenced by initial meticulous planning as partly explained above, and by the records developed progressively about the actual consumption of materials, surpluses or deficits as a result of perpetual inventory verification and the evaluation of the inventory holding costs as a whole. Corrective actions, as may be necessitated by the examination of such records will help improve the position progressively regarding excess stocks of individual items or short supplies of particular items (resulting from requirements being more than the initial forecasts). Such items can be clearly indentified and action taken either to dispose of the surpluses, if the stocks are excessive or to reduce the scale of procurement for the future, while for the short-supply items make provisions in the lists of future forecasts of requirements.

With regard to market research and processing of the enquiries etc., there are standard practice instructions generally issued by individual departments/authorities owing and operating the plant and equipment. This is the commercial aspect which could be conveniently attended to by a person who is competent to handle such work.

Besides the economy resulting from precision in scaling of requirements by virtue of consumption control and in sizing up the inventory of maintenance materials, consideration for economy arises in relation to quality of the materials also. Quality control can be introduced by a meticulous detailing of specifications of materials—technical, metallurgical, design and measurement-wise, before the material is procured. After receipt of the materials, careful watching of the performance of the materials in use on plant and equipment and a study of the observations recorded by the inspectorate and preventive maintenance organisation, helps to correct any deficiencies in the initial specification detailing for future procurement/supplies to be of better standards/quality.

Various attributes of the material management as described above, can be effectively realised in practice only if a properly qualified and experienced person heads this department. He must be conversant with the equipment and their maintenance requirements as well as with the financial and commercial aspects of the work. A critical senior officer only will meet the requirements of this department. He should also be fully competent in preparing a realistic budget. The normal tendency to play sage by exceeding all reasonable limits of requirement and to *leaving cutting and subsequently the responsibility for shortages of* excesses to higher authorities is not the right method. Budgetting has a very should educational effect on any department, to think in advance not only in terms of money but also in terms of technical means, material, spare parts, labour. A restriction to a limited amount of expenditures within a budget will have a healthy effect on the quality of maintenance. Only a sufficient maintenance will result in moving within the limits of an economical budget. For this to be achieved, the manager or the head of the department must know, somewhat at least, about the structure of the different plants and equipment, their weak points, their wearing parts about the foreseeable consumption about requirements of particular items to judge the demand of the departments making requisitions for materials.

A typical pattern of materials management organisation has been given in Appendix 4.1.

.14.8.9 *C.P.M. Applied to Construction, Operation & Equipment Utilisation.*

The Critical Path Method (CPM) has been actively used throughout the world by engineers in attempting to improve the planning and scheduling of construction programmes. This helps to introduce efficiency in construction operations and in equipment utilisation.

CPM divides the management functions into two distinct phases; planning and scheduling. Planning is defined as "the deciding of what should be done' and Scheduling is defined as the "determining of when operations should be done". Both are inter-related and have to be integrated for the purpose of CPM studies relative to any operations/programmes etc. Functionally, whoever, the deciding of the operations to the done amounts to preparation of a detailed chart giving description of the operations and indicating dependencies or inter-relation among these operations. The deciding of when operations are to be performed consists of the calculations regarding working time duration of each operation and of the earliest start time, latest start time, time of finish of operations of working-time schedules for individual operations and for the total operation of completing the work as a whole. These calculations, which relate to time only are generally referred to as 'Time only CPM'.

In his Article on the subject: "Critical Path Method applied to efficient construction operations and equipment utilisation", Prof. L.R. Schaffer, University of Illionis, U.S.A. (read at the International Road Federation Seminar in Chicago in February, 1969), has said, "only because of these calculations is it necessary to separate planning from scheduling in CPM; conversely, in techniques not dependent on this staged calculation procedure, the planning does not have to be separated from scheduling."

To clearly evaluate the level of application of the "time only CPM", it is also necessary to calculate the resources required to perform each operation in the working-time duration on the operation. For this evaluation to be effective, it is generally necessary to calculate the total amount of each resources required on each day of the project. As a deriving from such calculations, one can define the acceptable maximum total for each resource for stages of project duration. This in turn, helps in calculating the earliest start time schedule, and project completion time resulting from maintaining acceptable maximums for resouices. However, in practice, the resources flow may not be smooth. Accordingly, the time schedules as determined by ""Time only CPM" would have to be readjusted. This would involve the Programme Evaluation Review Technique (commonly known as PERT). Hence, for the CPM to be an effective tool for the management for controlling operational aspect of programmes of construction and equipment utilisation, the scheduling exercise has necessarily to take into consideration the resources flow also. This is termed as "CPM-with-Resources."

In the words of Prof. Schaffer, "CPM can be applied without calculation to foster efficiency in the planning of operations (Time only CPM), but only with calculation to foster efficiency in scheduling of operation (CPM-with-Resources). In the attempt to prepare a plan and schedule of construction operations such that efficiency in equipment utilisation is achieved, the calculation procedures affiliate with both of these classes of CPM have been invoked. When the maximal spanning tree calculation of planning in time only CPM is invoked, the equipment utilisation problem solved can be called "constrained resource problem"; when the calculation for scheduled alterations in CPM-with-Resources are invoked, the equipment utilisation problem solved is called Resource Levelling."

"Because equipment utilisation required the treatment of the para-meter of the resource/operation, it follows that equipment utilisation must be an exercise in CPM with resources."

Subject to meticulous planning for resources provisioning, the CPM can be used as a very effective aid in planning and scheduling of programmes of work for ultimate efficiency in utilisation of equipment.

Extension of application of the CPM is made even to the work of programming, planning and scheduling of repair and overhaul of equipment. Here again, the constrained resources do come to play a very vital role in making the programme successful or in upsetting it if spare parts and materials required for repair and overhaul of the equipment are not readily available.

Subject to scientific inventory control, method being adopted in respect of spare parts and a well organised maintenance materials management section operating CPM can be used for effective management of equipment utilisation.

Advantage of CPM technique, for planning of work, can broadly be regarded as:

(1) it provides a realistic integrated approach to planning and reduced guess work;

(2) it provides a pictorial representation of every item showing all its relationship with all other items;

(3) it highlights the significance of individual items so that localised decisions can be made;

(4) it facilitates quick restreamlining to meet changing or unpredictable conditions;

(5) it gives warning of possible trouble spots;

(6) it will provide reduction in cost and/or time to complete the work.

In order to keep pace with the contemporary thinking and practice in the field of management of construction work/equipment utilisation, it may be necessary to develop steps for CPM application relative to highly mechanised operations in various fields. Necessary assistance in this regard could be sought for from the Institutes of Management in India. The integar programming formulation for 'CPM net work with resources scheduled,' has also to be done with the assistance of the Institutes of Management. This may be taken up as an item of research by the CW&PC with one of the Institutes in India. Some senior officers could be trained in this field on an annual basis.

14.8.10 *Work improvement methods*

Although many organisations use the overall job planning techniques, few take the necessary steps to organise and plan the work meticulously to the lowest minute detail. It is often assumed or presumed that the person who has been chosen to organise and run operation or activity will obtain the most efficient use of men, material and equipment. This type of management control often leads to increased cost, because some Supervisors may have excellent organising capabilities while the others may not. Most of the time the supervisory personnel just think of getting the job done, not necessarily with the planning and instructions necessary for getting it done at the lowest cost. In the lower cadre at the foreman level the popular concept of "Kingdom building" exists and a workman in the group under a foreman often worship the latter as an idol. To correct this problem and to realise the most from the production tools it is necessary that the management carry its efforts down to the lowest level. This could be achieved by directing all energies into a framework that will bring the most benefit to the job at hand. By this process the directive efforts would have to be properly guided in set directions so that they don't lead to divergent directions.

To achieve this objective successfully what is necessary is to evaluate the effectiveness of the methods employed to do the work. This will involve a detailed study of phases of an operation and making a written plan of the same. The methods to do the particular operation will then be clearly laid down with due regard to the normal considerations involved in such planning viz. least cost, least time or maximum utilisation of existing facilities and equipment. Most often such pre-planning with regard to methods or operations is done based on experience gained relative to such operations on the job in the past.

No doubt standard methods have the advantage of familiarity and practice on the part of those engaged on operation of equipment etc. and in the process lower costs and fast execution of work is achieved. However, in practice, there could be some better way of doing a particular operation so that the execution is still faster and the costs are still lesser compared to the standard method. Development of a new method would involve:—

1. Record the job as it is being done, by observations, stop-watch study or any other visual aids, if necessary,
2. Analyse every details of the present method using the recorded observations and data by the process of flow process charts, motions studies etc. etc.
3. Devise new methods, raising the questions "Why, what, where, when, who and how?" holding discussions with all the senior persons assigned the responsibilty of the particular operational activity; and exchanging ideas with all the persons in managerial positions; and
4. Implement the better method.

While the function of recording the observations may not have to be explained in details, with regard to methods analysis techniques it is necessary that every aspect of the task under study must be questioned and defined the purpose of the job and of each phases or element of it, the job lay-out, each piece of equipment, each man and what he does. Failure to start from the outside and work into the details can often shadow the glaring results that we may be looking for. As the focus narrows on smaller segments the task as a whole can be better evaluated.

In relation to equipment the six questions given under item 3 above have already been dealt with though in an indirect manner. The reference to delay factors which result in substantial loss of production time covers these aspects. Such delays increase the cycle time of the operation; and most of the work with construction plant and equipment being of a nature of repetitive cycle; lends itself to time and method studies with the objective of availing of benefits of any corrective actions may entail through successive cycles. It is the highly repetitive nature of assuming construction operations that make them susceptible to the formalised technique of analysis.

Carefully analysed systems are both a method of recording and a means of communication. They are useful tools for analysing methods currently being employed and for develpoing new ones. Such a formal method of analysis is the best tool for helping to gather and sort out facts and to record the facts in a manner that is readily understandable. Simultaneously, it helps to determine the inefficient or wasteful processes or procedures involved in particular operational activities.

It is unfortunate that most of the users of equipment, in the process of living with the job, are oblivous of the need for improvement or for introduction of work improvement methods. Certain standard practices as laid down over a period of time are the best guide for most of the directional activities. Even the cost records and production records, as created, serve the mere purpose of accounting and not for analytical study. The effectiveness or otherwise of all the maintenance operations as carried out by the Maintenance Engg. Organisations is seldom evaluated.

In order that the real purpose of economy in operation is served by the management it is considered necessary that in every Sector where large scale of use of construction plant and equipment is made, the Central Co-ordinating Organisations should enlist the services of a Plant and Equipment Adviser. The principal function of the plant and Equipment Adviser would be to analyse completely the entire process of equipment management and control commencing from selection of equipment to the point of discard of equipment at the end of its economic life.

14.8.11 *Co-ordination*

In what has so far been dealt with in respect of management of equipment operation and utilisation, only such works have been taken into account where the equipment operation activities are centralised in restricted or contained areas. However, there are certain situations in which the equipment spread is over wide expanse of areas with few pieces of machines scattered over a number of works in 10 to 12 districts of a State. In such cases, there is need for central co-ordination on part of the officers managing a Central Mechanical Organisation. The functions of such an organisation have been dealt with in Chapter 12.

A very large proportion of the equipment in use in the country being of imported origin, the work of management of equipment operations involves contact and co-ordination with certain Departments of Central Government who formulate rules, policies and procedures, for import of equipment and spare parts etc. The extent to which such co-ordination is called for to be done has been clearly explained in Chapter 6.

For purposes of improvement in methods of management of equipment operations etc., it is also necessary that there should be a means of communication amongst users of similar items of equipment in different sectors/industries. Similarly, the users of such equipment should be collectively able to tackle common problems whether relating to technical areas or to rules, procedures and policies, through a common agency. A suggestion in this regard has already been made promoting the idea of establishment of a Standing Committee on Equipment planning. This has been dealt with in Chapter 6. A suggestion has also been made in that chapter about establishment of a Co-ordination Cell in the CW&PC and details of the items of work to be done by the Cell have also been defined.

14.8.12. *Incentive Schemes*

Yet another aspect for introducing improvement in operation and utilisation of equipment and consequently the efficiency of the management is the introductions of methods of incentive for the craftsmen and operating personnel as well as on part of the supervisory staff supervising these activities. Details of such incentive methods as were introduced by different equipment users on different jobs have been examined by the Committee. The details of the latest incentive scheme as introduced by the Mula Project in Maharashtra State are given in Appendix 14.3.

Though no conclusive thinking could be developed by the Committee in this behalf, in view of the diversity in the patterns of incentive methods introduced from time to time in the past on different projects, the Committee feel that this matter may make a subject for discussion in a Seminar, after finalising preliminary details in that regard in the Co-ordination Cell of the CW&PC. The Committee could not go further into this because of the very heavy agenda before them by way of terms of reference.

14.8.13 *Social Benefits*

For the management to control appropriately all the activities incidental to operation, maintenance and over-haul of equipment so that optimum utilisation thereof can be ensured, it is only necessary that the personnel directly engaged on these activities have a sense of personal security. This infuses in them a feeling of social well-being. The management has therefore to take concrete measures in this direction. These are briefly as follows.

The workmen should have the sense of belonging to an organisation. They must be assured on continuity in their service. The fear of being thrown out of service on completion of a particular item of work on which the equipment is used, should not loom large in their minds. For this to happen, proper planning is necessary on the part of the management to make advance plans for employment of the workmen on alternative jobs on completion of a job. Such conditions of stability in service, if created, would go a long war for the workmen to identify themselves with the work better.

The workmen also generally consider the benefits they derive from service specially when the job being done by them involves hazards to life. General Insurance against accidents of life would be one way to give an incentive to the workmen to be faithful to the employers and the management. Even though Workmen's Compensation Act does provide for some benefits of this kind, according to contemporary thinking the policy for general insurance of workmen may be adopted on all jobs involving use of construction plant and equipment.

Provision of entertainment facilities also helps the management to keep the workmen in peace. Provision of projectors for screening films and documentaries would make an item to be included in any plan.

Such projectors would be also useful for screening some technical documentary films for training purposes.

14.9 Role of Various Organisations in Achieving Efficiency in Management of Equipment

14.9.1 *The Role of Manufacturers of Equipment/suppliers of Equipment in Assisting Proper Management of Operation and Utilisation*

The manufacturers/suppliers of equipment also play a very important role in efficient management of operation and utilisation of equipment. Some important aspects relating to purchase of spare parts etc., have been dealt with in Chapter 4. However, from stand point of convenience of control in operations and efficient utilisation of equipment, a broad outline of the type of assistance, the manufacture/suppliers of equipment can render to the equipment managers, is given below: —

14.9.1.1 *Research and Development*

The research and development sections attached to the manufacturing organisations should make continuous advances on the technological front and should lead the manufacturers to consider introduction of newer models by incorporating improvements over the previous models so that these machines are more productive and less expensive on maintenance cost. Even the technical faults noticed and reported by the various users of equipment should be attended to properly and remedial measures taken in proper time, by causing the improvements/modifications better introduced in the subsequent production of machines.

14.9.1.2 *Quality Control*

Quality control on manufacture of equipment should be rigidly established. Most of the defects noticed in the equipment are attributable to improper quality control on the manufacture of parts and components, specially in respect of such components and parts as are manufactured by the ancillary industries and supplied to the original equipment manufacturers. The quality control organisation should take necessary action in laying down standards and tolerances for manufacture of these parts by furnishing detailed working drawings and specifications of materials to be used so as to make the equipment perform better.

14.9.1.3 *After-sale-service*

The service organisations of the equipment manufacturers should be properly developed so that they can keep close liaison with the users of equipment and sort out their problems with respect to the operation and utilisation of equipment. They should play a very important role in analysing the cause of low utilisation and recommend remedial measures necessary to be taken either by the users in properly utilising the machines or by the manufacturers for proper improvement on the products. These service organisations should have in their employment competent service hands who can analyse the defects of the equipment through inspection and advise the users to take remedial measures on the basis of their analysis.

Another important aspect of after-the-sale-service is the supply of spare parts to the equipment users as and when the requirements of the users arise. The equipment manufacturers/dealers should stock sufficient quantity of spare parts so as to meet the requirements of the users in time. They should not recommend bulk purchases of spare parts on "long-time buy basis" which would burden the users with big financial liability. For this purpose the dealers should stock the spare parts at Zonal/Regional stores (in the area where the population of the equipment is substantial) so that timely availability of spare parts could be assured. They should also establish the scale of consumption of spare parts and anticipate the future demands of the users with respect to their equipment in advance for keeping such items of spare parts in their stock.

14.9.1.4 *Technical Publications—parts catalogues, service bulletins, shop manuals, maintenance charts etc.*

It should be obligatory on the part of the equipment manufacturers/dealers to keep their users updated with technical information on developments in the machines, changed service and repair instructions, etc., by publishing service bulletins, shop-manuals, maintenance charts etc. so that the users are fully benefitted thereby.

These are the basic essential needs if the management of operation and utilisation of equipment, has to be efficiently and effectively achieved.

14.9.2 *Role of States*

The Central Mechanical Organisations in each State should be established in a fulfledged manner to execute the following functions:—

(a) for preparation of annual plans for distribution/allocation of available equipment to works according to fixed priorities.

(b) for centralising procurement of equipment so that minimum investment is made in purchase of new equipment, while timely disposal of surplus equipment is made on works concurrently in progress/under execution.

(c) for making suitable arrangements to provide suitable and adequate facilities for maintenance, repair and overhaul of equipment which is employed on jobs of small duration or where the equipment spread is wide.

(d) to organise and enforce inventory control spare parts so that adequate stocks are created with minimum investment.

(e) to formulate a sound equipment replacement policy based on proper evaluation of equipment economics relative to particular makes and models of machines.

(f) to compile relevant technical data and create proper records of reference relating to, performance of various machines of different makes and categories, norms of production therefore, related to specified job conditions, maintenance and repair costs, depreciation accounts etc. etc.

(g) to arrange for disposal of unserviceable equipment or rehabilitation of absolute surplus items of equipment and spare parts, through effective co-ordination and liaison with other users of equipment in different States/Sectors.

14.9.3 *Role of users of equipment*

1. Meticulous planning of equipment operation after making appropriate selection based on economy studies of different alternatives for combinations of equipment relative to well defined job conditions, quantities of work and time schedules, agency of work whether departmental or contractors etc. etc.

2. Creating an equipment Organisation based on principles of specialisation, delegation of authority commensurate with latest technological developments, operative research or development and method studies etc. etc.

3. Rigid observation and enforcement of principles of Preventive Maintenance through proper and adequate caretaking of equipment and record keeping.

4. Organising unit replacement of components for expedition and economy in repair work.

5. Planning utilisation of equipment on the job on long term basis to avoid its idle time (for want of work).

6. Training.

7. Creating/establishing suitable Materials management organisations for efficiency in procurement and enforcement of inventory control.

8. Watching technical performance of equipment and costs of operation, maintenance and repairs so as to clearly determine the reasons for increase in cost if any and relative these to improvements/measures of control called for in the technical areas.

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14.10 **Computors—A Controlling Aid for economy in Use of Equipment**

Electronic computors are becoming dynamic tools in design planning and management of construction/production jobs. These help immensely in integration of engineering and fiscal data and in simplifying the process of finding specific information pertinent to particular problems.

The problem common to all users of eletronic computors has been the large number of independent programmes and systems of programmes required to complete a project or running an industry involving extensive use of equipment for production. Because the programmes are independent, the source data must be input for each programme although it may be the output from some previous programme. Further integration has to be developed of the total engineering system which is defined to present the key data from each task performed in the related jobs reflecting clearly planing, design, construction and maintenance of a facility. Existing programmes keep getting modified or these are written to conform to this system; and the programmes necessary to link these existing programmes together are also to be written.

In relation to equipment, programmes and tasks to be performed would include selection of equipment production, maintenance and repair, warehouse stock and inventory control, salary and labour distribution, equipment ownership and operating costs and their distribution, availability, utilisation and operational efficiency of plant and machinery, integration of data for economic life of equipment etc., etc. Quantities and costs would be further integrated. These would clearly illustrate the complexity of data/information which has to find compatibility in use of computors.

The computor approach is new and relatively untried. More experience is needed in the practical application of the new approach since this entails economy in time and costs in solving the complex problems relative to construction equipment. In one of the studies made at the Stanford University, U.S.A., it has been revealed that computor time is worth about U.S. dollers ten only while two years of technician's time required for carrying out a particular exercise to arrive at a proper result would cost US $ 18000. The problem in question related to equipment replacement policy (equipment of a particular category in relation to a specified item of work).

There is a paucity of knowledge in the area of construction equipment policy. More research is needed to give the owner a better opportunity to maximise his profits. With more sophisticated technology becoming available to develop a policy, it will take a lot of applied research to put these new ideas into effect. It will, therefore, be necessary to train some of the Engineers in every sector, using construction plant and equipment, in the science of computation of basic elements and variables which should be integrated to develop equations for processing these through the electronic data processing machines/computors. Assistance in this regard can be sought from Indian Institutes of Management. A few young Engineers could as well be deputed for training abroad in this science. The Department of Civil Engineering, Stanford University, U.S.A. have done a lot of research in this particular field. A number of papers published by Professor James Douglas on the subject of Economic Replacement of Equipment, obsolescence, production by construction equipment etc., etc., make a very useful study of the science behind the subjects and the controlling aids that can be gainfully used for rapid solution to certain problems.

14.11 Views of eminent Indian Engineers on Pattern of Organisation and Management of Construction Plant and Equipment

The Members of the Committee have also availed themselves of the views of some of the eminent Indian Engineers, who retired as heads of engineering organisations, or are in top level management posts. They were kind enough to favour the Committee with their views in writing. The following are the extracts from the communications received from them:—

1 *Shri M. R. Chopra, ex-Chairman, CW&PC, Vice-Chancellor, Roorkee University*

For proper maintenance of heavy Plants and machinery, control of spare parts and disposal of machinery and spare parts, it is considered necessary that except for major and some special projects, special units should be set up in each State. These units should plan for requirements and prepare specifications of plants and machinery required, keep history of working and overhauling of each machine, plan for purchase of spare parts required for overhaul and field repairs, keep inventory of all spare parts in the unit, look after storage of equipment after completion of work at a project, look after overhaul of the equipment, take action for the transfer and transport of equipment from one project to others and look after disposal and rehabilitation of surplus equipment etc., etc.

These units should look after the heavy construction plants and machinery only and not small items like pumping sets etc.

All projects where the value of the equipment is over 2 or 3 crores of rupees should be treated as units but these may work under the control of project authorities i.e., there will be a no. of units in a State. Each of the unit should be under the control of a Superintending Engineer.

Overall control of the various units in a State may rest with one or more Chief Engineers, depending upon the number of units in a State.

2 *Shri N. G. K. Murti, Chairman and Managing Director, Water & Power Consultancy Services (India) Ltd.*

There should be a Central Mechanical Pool in each State. Unfortunately in the decade ending 1970 in some of the States, some regional thinking intruded and the Central Mechanical Unit became less and less effective in implementing the objectives for which it was created.

The project Mechanical Engineer must be incharge of the fleet and he must work in close liaison with the project Engineer. Both must understand and appreciate each other's position and subordinate their personalities to the common good i.e., for performance on the project. Site workshops cannot be just servicing in nature, but also be capable of handling certain seasonal overhauling and repairs because of consideration of time and cost evolved in getting these operations done at the Central Workshops.

Obtaining the spares needed in time cannot be solved by over-stocking spares. This can only be achieved by allowing each State a small blanket foreign exchange sanction commensurate with the cost of Plant in use and clearance of unlifted spares over 10 years.

3 *Lt. Gen. R. A. Loomba, retired Engineer-in-Chief E-in-C's Branch, Army Headquarters, and presently, Chairman, Board of Directors of M/s. B. E. M. L.*

(i) *Integrated approach.*

Use of Plant and Machinery cannot be considered in isolation. It should be considered as an integral part of the project and its various aspects should taken into account from the planning stage of a project to its completion.

(ii) *Selection.*

When an equipment is selected, it should be tried under local conditions and suitability established. Standardisation of equipment is essential to reduce the varieties.

(iii) *Control.*

Plant and Machinery should be under the Chief Executives on the grounds i.e., Superintending Engineer, or Executive Engineer. A Chief Mechanical Engineer is needed at the central Headquarter to coordinate all the technical aspects.

(iv) *Provisioning of spares.*

We should aim at getting initially at least one year's maintenance spares in the case of indigenous equipment and two years maintenance and one year's overhaul spares in the case of imported equipment. Provisioning procedure should ensure that at no stage surpluses or deficiencies occur.

(v) *Training.*

It is imperative that the operators and technicians handling the equipment and Engineers in-charge also get suitable training.

(vi) *Equipment analysis.*

A periodic appraisal of the over-all performance of the machines should be carried out objectives for the performance of the plants should be laid down and reviewed occasionally to see if these objectives are achieved. A plant intelligence cell may be established.

4 *Shri K. S. R. Chari, Chief Technical Advisor, Ministry of Mines and Metals, Government of India.*

Development of indigenous manufacturing capacity is the only way to bridge the tremendous gap between the availability and demand for equipment.

Consumption of spare parts for earth-moving operations is considerably high and it is for this reason that adequate provisioning of spare parts is important.

Greater emphasis should be laid on preventive maintenance and for this proper training of operators and maintenance crew is important.

5 *Shri Moti Ram, Consultant, Ministry of Irrigation and Power, Government of India.*

When any large project requiring procurement of a large amount of machinery is taken up, it is necessary to draw carefully list of the equipment to be procured. This should be done by the project authorities in close consultation with a senior mechanical engineer who should preferably be the person to be put in charge of the mechanical part of the project. No attempt should be made to economise on the workshop tools at the cost of efficiency Where work is spread out mobile workshops may be arranged to avoid haulage of the units to central workshop.

Where more than one number of any machine is required, all the units procured should be of the same make. This will also reduce the inventory of spares.

It is preferable to write off a few unused spares at the end of a machine's life than to have an expensive unit put out of commission for want of a part costing few dollers.

The time of receipt of the various items should receive special attention so that a unit of the machines may not be idle for want of some category of machine. The opinion of a senior mechanical Engineer at the planning stage should, therefore, not be lightly disregarded if he is to be held responsible for the performance of the equipment.

A central cell headed by a Mechanical Engineer is desirable only if a number of projects are in progress in a State and frequent transfer of equipment from one project to the others are likely.

To be effective, the central agency attached to C.W.&P.C. should be headed by an officer of the rank of Chief Engineer, who should deal directly with the agency at State headquarters where is exists or with the project authority in other cases.

It should not be necessary for the C.W.&P.C. to send all foreign exchange applications received from the projects to the Finance Ministry through the Ministry of I&P. This process is time consuming and should be unnecessary if the central Agency in C.W.&P.C. is staffed with mechanical engineers of adequate experience and status.

6 *Shri A. K. Char, Consulting Engineer.*

The persons incharge of the project should be given the authority commensurate with the responsibility. There should be no divided responsibility.

The maintenance and operation of equipment should not be left to any subordinate agency.

Irrespective of to which discriptive the project Manager belonged to, as it is his ultimate responsibility to deliver the goods, he should be the person to be entrusted with the organisation management and operation of the Tools of production assigned to the job. It is for him in turn to select and entrust the operation and maintenance of the job to a suitable person answerable to him.

Subject to the condition of undivided responsibility in a project there must be a well defined organisation within the above frame-work clothed with adequate power to organise maintenance and operate on an agreed overall plan.

14.12 Summary of Observations and Recommendations

In relation to construction plant and equipment, effectiveness of management control is reflected in optimum utilisation of equipment, maximum productivity and least cost of the end-product produced by the machines. Briefly, this amounts to production control and economy control. 'Organisation' is the machine of management in its achievements of these ends. A system of coordinated activities with due regard to policies, authorities, responsibilities and duties/activities makes a sound plan for the organisation. Functional coordination in planning, execution and review helps controlling the production and economy provided a level and line of authority and the degree of responsibility at each level are clearly defined for frictionless operation of the activities.

Management methods and techniques are continuously getting better to keep pace with the modern trends in industries the world over; and the impact of this is clearly felt in all industries using the construction plant and equipment. However, conceptually the pattern of organisation leaves something to be desired. There are certain voids and deficiencies which are not in conformity with the basic principles and objectives of a sound Organisation.

Production control function is performed by getting the job done. The economy control function is limited to controlling the visible costs only even though this involves a continuous research in methods of improvement of operations or their management. The basic requisites of such methods of improvement viz., operations research, time and method studies, methods analysis techniques which require the attributes of an acquiestive mind and a proper attitude to changes, are not fully provided for.

In order to improve the efficiency in management, operation and utilisation of equipment, it is necessary that the machine of management Organisation, should be more suitably developed and greater emphasis laid on method improvement techniques.

Recommendations.

1. For proper management operation and utilisation of equipment, the functional control on operation, servicing, repair etc., of equipment shall be assigned to one suitable organisation only on unitary control basis, under an Equipment Manager.

The organisation shall be responsible for selection of equipment, care of equipment, record keeping, value analysis, cost effectiveness and defect analysis, besides the normal functions of maintenance engineering.

2. The size of the organisation and the type of administrative control (defining the life of heirarchy) shall be determined by the size of the fleet of equipment value-wise, as per following table: —

Equipment value (Rupees)	*Organisation*
(a) 7.5 million to 10 million	Executive Engineer
(b) 25 to 40 million	Superintending Engineer
(c) 50 to 70 million	Additional Chief Engineer
(d) Above 70 million	Chief Engineer

3. For functional control of large-sized fleets of equipment concentrated at single locations, the distribution of work will be so made that specialisation and economy in investment costs can be achieved besides ensuring expedition in repairs (reducing downtime of equipment to the minimum) and better quality of repair and maintenance work.

4. The personnel supervising the operations of equipment should be suitably trained. The training of the executives should be such as to make them clearly understand the functions of planning, execution and review, in relation to specific positions held by them. The Foremen, Chargemen, Supervisors and Overseers should also be similarly trained so that the 'How' and 'Why' of a job can be clearly understood by them.

5. The syllabi prescribed for Engineering Courses in the Technical Institutes and Universities should additionally cover the following: —

- i. Construction methods and techniques.
- ii. Selection of equipment for given job applications.
- iii. Planning of equipment for better production and economy in end cost.
- iv. Maintenance engineering.
- v. Equipment economics.

6. Every project estimate shall include a clear design of the plant lay out and facilities required based on exercises of economy.

7. Provision for continuous research and revision of the methods for operation of equipment, for improvement of production by machines, will be made by constitution of the Operations Research Cell, and/or Time and Methods Study Cell.

8. Accumulation of performance data production and costs shall be made by creating proper records, under the direct supervision of an Engineer so that corrective actions, if any necessary (based on analysis of the information so recorded), can be taken for improvement in utilisation, productivity and reduction in costs in various segments of work.

9. Materials management should be assigned to properly qualified and experienced persons.

10. Senior officers managing equipment operations and utilisation shall be trained in net work techniques so that planning and scheduling of construction programmes and operations and utilisation of equipment could be properly achieved.

11. Young engineers holding responsible positions in the management shall be trained in the use of modern management controlling aids—computorisation etc. For computorisation to be possible, assistance shall be taken from the Management Institutes in the country for developing a clear list of items of information etc., that may be necessary for integar tabulation. Necessary steps for codification of cost centres and cost elements, which are the prerequisites for such a programme shall also be simultaneously taken.

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